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WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 35.

GEOLOGICAL REPORT

UPON THE

GOLD & COPPER DEPOSITS

OF THE

PHILLIPS RIVER GOLDFIELD,

BY

HARRY P. WOODWARD,
Assistant Government Geologist,

WITH WHICH IS INCORPORATED A

Description of the Crystalline Rocks of the District,

BY

E. S. SIMPSON and L. GLAUERT.

Issued under the authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

WITH TWO MAPS, EIGHT PLATES, AND SEVEN PHOTOGRAPHS.

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1909.

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PREFATORY NOTE.

The work of examining the Ravensthorpe District of the Phillips River Goldfield was commenced in the middle of the year 1907 by Mr. H. W. B. Talbot, Topographical Surveyor to the Department, who spent several months upon the construction of a feature map upon which contour lines were accurately laid down at intervals of ten feet.

In April of the present year I commenced the Geological examination, but owing to the absence of the Government Geologist, was unable to devote my whole time to it, therefore the mapping of the rock formation was carried out by Mr. Talbot under my supervision and it is only just that I should here pay him the tribute by stating that this work was done in a highly satisfactory manner.

From a geological point of view this district is the most complicated yet examined in this State, and in consequence of exceptional interest, the only point for regret being that these formations could not be observed in their unaltered condition owing to the fact that in only one or two instances have they been penetrated below the ground water level (30 to 100 feet), whilst the deepest mine is only 400 feet and still in the fracture zone.

The report has been divided into three sections, the first consisting of the Geology, etc., from a field point of observation, the second section of the laboratory notes upon the rocks by Messrs. Simpson and Glauert, whilst the third is devoted exclusively to a description of the mines examined upon this and previous occasions. The whole is accompanied by a geological map in two sections, one embracing the western area which includes the Ravensthorpe Mining Centre proper, whilst the other or eastern takes in those of Mt. Desmond and Kundip.

The preparation of a report upon an area that has previously been described by other qualified men is always a difficult and unpleasant duty, for at the best of times opinions must differ, whilst in so complicated a district as Ravensthorpe these are apt to do so more widely; but since both Messrs. Montgomery and Blatchford in putting forward their views, have stated that these were only provisional owing to the lack of a detailed geological map, I feel sure that they will not look upon these points of difference as in any way antagonistic or critical but simply as conclusions arrived at from my own observations under more favourable conditions than they experienced.

HARRY P. WOODWARD,

30th November, 1908. Acting Government Geologist.

PART I.—Introduction.

This Goldfield, which was originally proclaimed in 1900, is situated upon the Southern Coast, its port of Hopetoun being about 150 miles to the eastward of Albany from which there is a weekly mail boat service.

Hopetoun is now connected with Ravensthorpe, the official centre, by a Railway line about 40 miles in length which also serves the mining centres of Kundip and Mt. Desmond.

The portion of this field which has been geologically mapped embraces the whole of the known mining area with the exception of the small centre of West River and Mt. Purchas, which were not considered to be of sufficient importance to be included, since the work entailed would have been very considerable. The area covered by the geological map is about 85 square miles, the whole of which has been also topographically surveyed and contour lines accurately laid down at 10 feet intervals of elevation above the sea level.

The following table gives the rainfall returns as supplied by the Commonwealth Meteorologist:—

	Ravensthorpe	Hopetoun
1902	17.07	18.86
1903	13.60	17.93
1904	19.49	28.20
1905	14.90	17.84
1906	14.78	19.90
1907	11.84	16.07
Mean of 6 years	15.28	19.80

PHYSICAL FEATURES.

The main and most striking feature of this district is the Ravensthorpe Range which is visible from the coast; it starts at its southern end upon the eastern side of the township of Kundip, and runs in a generally north-westerly direction for a distance of about nine miles, presenting a bold steep escarpment to the south-west, whilst upon the north-east it is not so precipitous, neither does it present so range-like an appearance since the adjoining plains upon this side are more elevated. It has been described as a horseshoe-shaped range sweeping round from a north-westerly course to a more westerly one, but more correctly speaking it consists of two sections, the southern of which strikes west of north and the northern north of west, whilst between the two a sharp line

of dislocation has taken place at which point it has been cut through by the Cordingup Creek, which flows to the eastward in a steep gorge-like valley. In its southern section the two highest peaks are Mt. Desmond and Mt. Decker which attain an elevation of 1,150 and 1,050 feet respectively, both being conspicuous land marks since they dominate considerably the remainder of the Range.

In the northern section the Range takes a sharp turn and runs upon a more westerly course but although its height is generally greater than the southern portion and it attains an elevation of 1,200 feet above the sea level, it is not so imposing owing to the fact that there are no very conspicuous peaks and the country immediately to the southward is more hilly.

From the first mentioned section in the vicinity of Mt. Desmond a high ridge runs from it in a westerly direction, then sweeping round to the northward rejoins the range in its northern section at a point north of the Floater mine. This ridge forms a basin with the Ravensthorpe Range and divides the watersheds of the Jerdacuttup and its tributaries, which flow to the eastward from the Steere and Phillips Rivers, which flow to the south and west.

This basin-like area is drained by the Cordingup Creek and its principal tributary, the Cattlin Creek, which flow over large and rich alluvial flats uniting near the site of the old smelting works below which the combined streams flow in a gorge-like channel through the Range in an easterly direction, upon the north-eastern side of which it junctions with the Jerdacuttup River.

The western area of this map is drained by the Annabelle and Stevenson Creeks, which flow in a southerly direction, and the south-western portion by the Manyutup Creek flowing in a westerly direction, all of which are tributaries of the Phillips River.

The district between Mt. Desmond and Kundip is drained by the Steere and Western Steere Rivers, the former of which rises near the Elverdton mine and flows in a southerly direction along the foot of the Ravensthorpe Range, being fed by numerous water courses which join it both from the east and west.

The Western Steere rises to the south-west of the Elverdton mine and follows a course approximately parallel with the Steere River, with which it unites to the southward of the area covered by the map.

Between the Cordingup and the Cattlin Creeks there are some extensive and rich alluvial flats covered with gum trees of considerable size, but elsewhere the country is rough or undulating, being broken by numerous gullies.

With the exception of the granite and elevated sand plain areas, which are only covered by low stunted vegetation, the ridges and gullies are densely covered with mallee intertwined with creepers, which are a great hindrance to a person walking off the tracks. The soil of the large flat, as well as the greenstone area in the north-western section of the map, is a rich red or dark brown

Photo. H. W. B. Talbot. Neg. 413.

The Ravensthorpe Range, with Mt. Chester tunnel.

clay admirably suitable for wheat-growing, whilst the granite area, with the exception of some dark and light clay patches, is of a poor sandy character similar to that of the elevated sand plains.

The underground water supply has proved to be plentiful, but invariably salt or slightly brackish at best, the latter being generally of an alkaline nature and met with in the granite area.

GEOLOGY.

A transient glance at the geologically coloured map will at once convey to the observer the intricate character of the dyke system and the variety of rocks exposed at the surface within this limited area, but only a slight idea of the complex character presented by the crystalline series in this district can be formed even when it is stated that these belts and patches of colour with one symbol as representative of one class of rocks are in reality very often further intersected by numerous minor dykes or veins of too small a size or of too great a similarity in their weathered state to be mapped in.

Besides the complex of crystalline rocks exposed, a further series of what may possibly be old and highly metamorphic sedimentary are also represented followed in ascending order by a more modern although probably fairly ancient series of sandstones, quartzites, and conglomerates, whilst further to complicate matters considerable tracts of the surface are covered by superficial deposits of clay or sand which for the most part effectually conceal the nature of the underlying rocks, although the general character of these may often be approximately arrived at by examining the composition of the weathered superincumbent material.

No geological age can be assigned to any one of the formations or groups of rocks in this district owing to the fact that organic remains by which such points are determined have not as yet been discovered, whilst should fossils be discovered in the sandstone series (which is the only possible one) no great advances in this direction will be made, since these beds are the most modern in the area.

Generally speaking, the north-western section or greenstone area is covered with clay, therefore no rocks are visible, their character being determined by the nature of the soil and work done by prospectors; in the central section however, the rocks outcrop in a practically unaltered condition and although of considerable complexity they are most easily determined and mapped in. In the range sections upon the other hand the whole series, although outcropping, is so highly altered even to depths of close upon 100 feet that it is quite impossible to determine with accuracy their true character, they are further complicated by a series of parallel interfoliated ferruginous lode-like bodies of a lateritic character.

In the following description these rocks have been divided into groups, the first, probably the oldest constituting the

Ravensthorpe Range, after which the series is called, consist of weathered basic schists and serpentines, the former of which are intersected by numerous parallel ferruginous bodies and ferruginous banded quartzite reefs and often capped by laterite whilst the latter is usually covered by a superficial deposit of magnesite.

The second series are the granites with their intersecting dykes of diabase, diorite, quartz diorite and kersantite, in the schistose portion of which many of the copper dykes are situated, whilst others lie at its contact with the greenstones.

The greenstone series next being apparently the magnetic nucleus from which the basic dykes referred to above radiated into the granite. This series is intersected by pegmatite, felsite, quartz diorite, and camptonite dykes. Following in ascending order are the Kundip series of sandstones, which must have at one time covered a considerable portion of this area, since small outliers and detrital material occur at places all over it. They are of interest in so far that they are the only distinctly stratified rocks of the district.

The superficial, travertine, laterites, and alluvium are of little interest but the lodes which are treated separately are extremely so, the great drawback being the very limited extent of the workings, particularly in depth, which precludes the possibility of so thorough an investigation into their character as could be desired.

Ravensthorpe Range Series.—Probably the oldest series of rocks in this district are the highly weathered and altered schists which form the Ravensthorpe Range, but notwithstanding the fact that they rise to a considerable elevation and have been cut through by the Cordingup Creek, at no point are they exposed in an unaltered state.

These rocks at their outcrop are of a light brownish colour and consist of kaolin, silica, and iron, the latter being in the form of limonite (hydrated oxide of iron); they have a marked lamination which runs in a north-westerly direction identical with that of the Range and are traversed by numerous parallel lode-like bodies of iron ore and a series of banded quartzite veins of considerable size and great longitudinal extent.

These ironstone bodies have been quarried at one or two points for flux for the local smelters, but so far as tested they have proved to be of a comparatively superficial character; a shaft at the Iron Knob sunk to a depth of about 70 feet did not pass through anything but kaolinised rock containing small veins of oxide of iron. At one or two points copper stains have been observed, but so far no appreciable quantity of the ores of this metal; their occurrence has, however, been interpreted as indicating that these ferruginous bodies are the gossans or iron caps of copper lodes.

Upon a lease called the Mt. Chester, situated close to Mt. Desmond, one of these bodies is replaced for a length of about 250 yards by a manganese (pyrolusite and psilomelane) lode which at a

Photo. H. W. B. Talbot. Neg. 415.

The Iron Knob
(Ironstone flux quarry.)

point where it was cross-cut at the surface measured 20 feet in width.

With the object of testing this lode at a depth an adit level was driven for a distance of 424 feet into the steep hill face 90 feet below the outcrop. This is of considerable interest since it is one of the few points at which this series may be examined, otherwise than at the surface. The rocks in this drive present a well-marked schistose structure, the strike of the folii being north-westerly with an inclination of from 70 to 75 degrees to the south-westward. They are mostly white, light yellow or grey in colour and highly kaolinized but less hard than at their outcrop since the cementing oxide of iron is absent, it having segregated into the leaching channels.

A specimen [7828] from this drive exhibits a banded structure which varies in colour from grey to yellowish white, the whole being pitted by small cavities representing casts of marcasite (white iron pyrites) all trace of which mineral has been entirely removed.

In this drive no ferruginous body of any size was cut notwithstanding the fact that between its mouth and the manganese lode outcrop at the surface a large one is exposed; this appears to be conclusive evidence that they are of no vertical extent.

The Mt. Decker tunnel which is close by is also of interest, but not nearly so much since it has been driven in the direction of the rock laminations, therefore little variation in its character occurs; neither does it throw any light upon the nature of the ferruginous bodies.

At the southern end of this belt of rocks a considerable amount of work has been done upon them in the Gem and Two Boys leases, but owing to the nearly horizontal lie of the formations, only a moderate vertical depth has been attained, therefore those encountered are still of a highly altered character, being white and almost pure kaolin near the surface, whilst at the lowest levels they pass into undoubted greenstone schist in a very much weathered condition.

Owing to the elevated position occupied by this apparently old land surface the changes wrought by oxidation, hydration, and subsequent leaching upon this series, which have extended over a considerable period of geological time, have so completely altered their character to a greater depth than at present explored that it is impossible to state with any degree of confidence what their origin may have been, both Mr. Montgomery and Mr. Blatchford lean towards the metamorphic sedimentary theory; whilst the former authority has made further the suggestion that the ironstone gossan-like bodies may possibly be the caps of interbedded cupriferous lodes.

If this sedimentary origin theory is the correct one these rocks must, previous to their leaching, have been altered by heat into

greenstone, in which case during this metamorphism the iron in the form of pyrites must have segregated to a very considerable extent into parallel belts or zones following the induced foliation which may or may not have been in uniformity with the original bedding.

A careful examination however, made under more favourable conditions than were possible for former observers, leads to the conclusion that the rocks comprising this range are of igneous origin and are of a similar greenstone type to those met with upon the goldfields generally. This is further supported by the occurrence of a belt of magnesite capped serpentine in the centre of and following the same direction as the range, which rock from its petrological character is clearly an alteration of the hornblende series.

The parallel ferruginous bodies which intersect this entire series with the exception of the serpentine have in no instance exhibited any of the recognised characteristics of fissure lodes, for neither do they possess the marked definition usually noticeable between lode formation and country rock nor, so far as tested, have they proved to be of any vertical extent. In composition at the surface they are identical with the laterite deposits which cover and cap a considerable extent of these ranges and in consequence they are most probably of similar origin, their parallel character and continuity being due either to the superior capillarity of certain belts of schists which have allowed of the ascension of ferrous solution or to the fact that a series of highly basic ferro-magnesian dykes have been intruded along the foliation planes of the primary greenstone schists, whilst the weathering of their outcrops has yielded belts of highly ferruginous laterite.

In support of the basic dyke theory, a reference to the map will at once demonstrate the fact that the course assumed by these parallel ferruginous bodies is in general uniformity with that of the basic dykes in the granite area which lies immediately to the westward, certain irregularity in these latter being due to the character of the rocks since in a schistose series it is only natural that dykes should assume a greater degree of parallelism in conformity with the foliation than in a more massive crystalline rock-like granite.

The conclusion arrived at is that these ferruginous bodies are not lodes but simply laterite cappings which follow the outcrop of a series of ferro-magnesian dykes whilst the enclosing rocks or country are altered greenstone schists of probable igneous origin.

Besides the ferruginous dykes referred to above there are a series of banded ferruginous quartzites (jasper in part) identical with those met with upon the Eastern Goldfields. These are of even greater longitudinal extent than the more basic series and are apparently of very considerable antiquity since the boulder and pebble conglomerate beds met with near Kundip are very largely composed of them.

Photo. H. W. B. Talbot. Neg. 414.

Showing peculiar weathering of Banded Quartzite.

They in all probability represent shearing lines since they have a course parallel to that of the foliation of the schists the banded structure being due to the gradual deposition from ascending mineral solutions as the fissure slowly opened owing to the contraction of the rocks in the process of cooling, the layers of differing material being due to varying composition of the depositing solutions over a long period. Up to the present bodies of this character have nowhere proved to be of any direct economic value in this State but that they have played a hand in the deposition of gold is proved by the fact that where they have intersected auriferous veins the latter are of much greater value in their immediate proximity.

The whole of the area occupied by these rocks is densely covered with scrubby vegetation, whilst considerable tracts upon the elevated portions are capped by sheets of laterite.

The Granitic Series.—Under this heading are included the intrusive granites and intersecting basic dykes which occupy a central and southern portion of the area covered by the map between the Range and the township and to the southward of the latter. They are in all probability a portion of the series met with upon the southern coast which extend from the Warren River upon the west to Israelite Bay upon the east.

These rocks for the most part outcrop at the surface in a practically unweathered condition, therefore owing to the scarcity of soil only scant herbage of a hard scrubby nature is able to exist and in consequence their mapping is made exceedingly easy. At one or two points however the decomposition of this rock has yielded a white or dark grey clay upon the latter of which timber of considerable size or patches of dense mallee often flourish.

Extensive tracts of superficial deposits of sand are also met with in places which completely mask the character of the underlying rocks, but from the nature of these deposits it may be inferred that they were primarily derived from the weathering of the granites although possibly at a subsequent period they formed the sandstones of the Kundip series.

There are also considerable tracts of alluvium which are particularly well developed in the basin-like area drained by the Cordingup Creek, which were originally covered by fine salmon gum timber, but this has to a very great extent now been cut down either for mining purposes, for fuel requirements, or with the object of clearing the land for farming since the soil is of a very high quality.

These granites belong to the soda-lime felspar group, and vary very considerably in character and composition from fine-grained compact rocks to very coarsely crystalline ones whilst they sometimes contain considerable quantities of hornblende, particularly when in the proximity of basic dykes.

The whole of this area has been shattered by the basic intrusions to the north-west from which magma numerous greenstone

dykes and masses diverge intersecting the granites in a general south-easterly direction with a degree of parallelism that is remarkable.

These dykes consist for the most part of diorite or amphibolite possibly resulting from the alteration of diabase, which rock is exposed at one or two points in the form of dykes having an east and west or north-easterly course cutting through the normal greenstones and therefore of probably more recent origin. Besides the diabase there are a series of large quartz diorite dykes which break through all the others in a north-easterly direction; these, near the Elverdton mine and to the southward of it, are well developed and of very considerable size, whilst this class of rock is only represented by one or two quite small dykes in the Ravensthorpe section of the map.

Besides the dykes which attain sufficient dimensions to be mapped in there are belts of country particularly in the contact zone, in which the basic veins are so small and so numerous that in some cases hand specimens exhibit these whilst further the majority of the copper lodes are also greenstone dykes situated at or near the contact, but these will be more fully described later on.

Fringing the eastern edge of this area and abutting on to the southern section of the range, in the locality of the Elverdton mine, is a belt of schistose granite, the foliation of which follows the prevailing northerly trend, and this class of rock contains some of the best defined and richest cupriferous dykes of the district.

In the granite area the basic dykes are very easily traced by the character of the vegetation, the rich red soil derived from the weathering of the latter, supporting a much more luxurious growth than the poor sandy soil of the granite area. In other places where less weathered rocks are met with at the surface, the dyke appears like dark bands which can be traced without any difficulty. At one or two places there are what appear to be fault lines crossing the dykes; if this is the case the displacement must have been very considerable, in fact rather too much so, to be a fact, therefore, the more probable solution of this phenomenon is that the dyke fissures have suddenly terminated abruptly upon shearing planes. There is very little doubt but that considerable faulting has taken place, an instance of which, on a minor scale,, is visible in the Elverdton mine, whilst the gap in the range, through which the Cordingup creek flows, is also one of them upon a larger scale.

The Greenstone Series.—This series of rocks occupies the extreme north-western portion of the area geologically mapped, beyond which they extend according to Mr. Blatchford in a comparatively narrow belt for a distance of about 12 miles in the direction of Cocanarup.

Most of this greenstone area is covered with a layer of from two to six feet in thickness of red loam or clay, which completely masks the character of the rocks, therefore, with the exception of those

Photo. 4.

Photo. H. W. B. Talbot. Neg. 417.

A Greenstone Dyke traversing granite country.

points at which these superficial deposits have been penetrated either by shafts or trenches, their nature can only be surmised.

It is, apparently, a magmatic intrusion from which off-shoots have penetrated and shattered the granite in a south-easterly direction, the massive greenstones themselves have also proved to be intruded by dykes of quartz-diorite, camptonite, kersantyle, pegmatite and felsite, whilst the quartz reefs which were worked for gold in the shallow ground passed into basic dykes at a depth.

This area was originally densely covered with mallee scrub, in which belts of good timebr were occasionally met with, the whole being usually much matted with creepers, which adds to the difficulty of its examination, whilst all positions must be fixed by traverse.

In and around Ravensthorpe the principal copper lodes are contained in large off-shoots of this rock, or at its contact with the granite, whilst at Kundip a mass of considerable extent also encloses the lodes.

The Kundip Series.—This series of rocks, which are most largely developed near the township of the abovenamed, consist principally of sandstone (often ferruginous), grits, quartzites (ripple marked) and conglomerate. They are, undoubtedly, of marine shallow water origin, their deposition taking place at a period when the existing Ravensthorpe range formed the coast line, since high up its flank are boulder beds, composed of water worn masses derived from the banded ferruginous quartzite reefs; these beds further from the range pass first into pebble conglomerates and then into quartzites, the latter being often of so white a character as to be mistaken for quartz.

In the northern section of this area this series is only represented by a few small isolated patches of highly ferruginous sandstone, these being the only remaining evidence of the once considerable horizontal extent of these beds.

Near the Explosives Reserve one of these small outliers occupies so peculiar a position that at one time considerable doubt existed as to its origin since in its general character it presents a striking resemblance to a dyke; however upon a careful microscopic examination of the rock it proves to be a ferruginous sandstone, and therefore must have resulted from the infilling of an open fissure with sand from the surface.

The sand plains or superficial deposits probably also belong to this series, the sand of which they are composed being due to the weathering of soft sandstone.

The age of these beds is uncertain, since owing to their shallow water origin the wave action would have destroyed all traces of organic remains, but is is highly probable that they belong to the Great Australian Bight series (classed as Tertiary), which extend along the south coast from the westward of Albany far into South Australia.

The Lodes.—So very little work has as yet been performed upon the lodes of this district, and this little with the exception of one or two mines, is confined to the zone above the ground water level, that it is premature to make a definite statement as to what the permanent character of these bodies will be at a depth.

They may, however, be provisionally divided into two groups or classes of distinct type, the first of which are basic cupriferous dykes, and the second are apparently siliceous and ferruginous deposits filling leaching channels along the rock jointing, and therefore give less promise of permanency.

Without exception, all the mining upon this field has been confined to the fracture zone, and with only one or two exceptions to that portion of it which is situated above the permanent ground level which may be called the zone of aeration, whilst that below may be termed in contra-distinction the zone of saturation, and since no mining has been carried on in the zone of cementation which would here be represented by the lower section of the saturated zone and the waterless ground beneath it.

In this district the passage from the zone of aeration to that of saturation does not appear to have produced that marked physical change in the character of the lode and ore which is so usually met with and expected, since unaltered rocks containing the primary sulphides occur at a considerable elevation above the ground water level, and even in some cases quite near the surface; therefore it will be better to discard the above classification, substituting that which adapts itself more closely to these local conditions, viz., into the oxide and sulphide zone, the former of which covers that portion of the lode in which oxidation, hydration, and weathering have taken place, and the latter that in which the rocks in an unaltered form carry primary sulphides.

The question of primary sulphides occurring above the ground water level has been carefully investigated, and the only solution which can be arrived at is that the great density and impermeable character of the rock matrix have resisted weathering, and thus protected the enclosed ore from the oxidising influence of the descending aerated water.

The lodes at the surface present all the characteristics which are usually associated with deposits of copper ore, viz., ferruginous gossan outcrops (iron hat) of often considerable size and usually highly siliceous, the only indication of copper when present being minute traces of green carbonate.

These quartz and gossan outcrops usually carry fairly high gold and silver values, so much so in many instances as to cause them to be classed as auriferous lodes, whilst copper if present occurs in such small quantities as to be of quite a secondary consideration.

In prospecting these outcrops in order to ascertain their copper values it has been necessary, in many cases, to sink to as great depth as 40 feet before payable ore was encountered, when it most usually consisted of a ferruginous mixture of both oxides and car-

Photo. H. W. B. Talbot. Neg. 409.

White Quartzite Cliffs near Kundip.

bonates (liver colour ore) with small green crystals of malachite contained in the cavities.

In this upper portion of the lode the ore occurs in bonanza-like enrichments either in a bunch-like form within the main body or more commonly in flat lenses upon one or the other of the walls. These have been called shoots by the miners, but since they are of purely secondary origin, and lack vertical continuity, this term has been decidedly incorrectly applied. The matrix or "formation," as it is usually called near the surface, consists of soft brownish clay which passes imperceptibly into weathered mica schist, then into schistose greenstone, and eventually into a solid basic dyke stone. Quartz is fairly plentiful in the zone of weathering, but below it mostly occurs in veins or layers which give the lode a banded appearance.

Both the gold and silver appear to be principally associated with the ironstone and quartz, a lesser quantity being carried in the copper ore whilst the percentage of these precious metals, particularly the gold, shows a marked decrease downwards in the lode.

The transition from the oxidised to the sulphide ores is usually sudden, there being no rich oxides and native copper capping a zone of secondary sulphide enrichment, but directly the solid rock is encountered, chalcopyrite occurs usually coated with green carbonate or more rarely coverite. ,

In the sulphide zone the chalcopyrite is associated with pyrites, marcasite and pyrrhotite (the latter largely predominating in the Cattlin mine), disseminated through the entire dyke mass or occasionally as lenses or pipes of ore upon one or the other wall of the formation.

In the unaltered sulphide zone there is an appreciable falling off in the gold and silver values, whilst a further steady reduction takes place even within this zone level by level downwards, thus clearly indicating that the higher values in the oxidised zone, and the upper portion of the sulphide zone are solely due to concentration, and to the deposition of gold from alkaline sulphide solutions.

Quartz too is largely a secondary mineral being deposited as metasomatic action has taken place in the lode channel, this being clearly demonstrated in nearly all the mines since lodes consisting almost entirely of quartz and ferruginous gossan at the surface pass into massive greenstone often almost destitute of quartz at a depth. The proportion of iron has also considerably increased near the surface, owing to its deposition from ascending solutions drawn to the surface by capillary action.

The fairly concentrated bunches of copper ore in the oxidised zone are evidence that secondary enrichment has taken place whilst the barren iron caps also indicate a leached zone, as however, no secondary sulphide enrichments occur, these bonanzas cannot as is usually the case have been derived from their oxidation. It is probable, therefore, that the carbonates and oxides of copper have

leached out of the lode cap by descending meteoric waters charged with organic acids, and subsequently redeposited as carbonates and oxides at a lower level when their solutions came in contact with the alkaline salts which the surrounding granitic rock contains in large quantities.

This alkalinity of the rocks, and in consequence that also of the ground waters has probably played an important part in the prevention of the deposition of secondary sulphide, since such water would immediately neutralize all acid solutions formed from the decomposition of the primary sulphides, and convert the copper directly into carbonates (as demonstrated by the carbonate coated chalcopyrite) therefore at the ground water level no acid solutions could be present from which copper could be deposited as a secondary sulphide upon coming in contact with chalcopyrite or marcasite.

As previously mentioned, traces of covellite are sometimes present coating the chalcopyrite, but since these are usually only met with along the lines of fracture it would appear that at these points a preponderance of acid must have been liberated owing to the more rapid decomposition of the ore, thus producing conditions favourable to the deposition of secondary sulphides.

At the deepest points of the richest mines the ore usually has a foliated structure, consisting of bands of quartz, greenstone, and chalcopyrite, or one of the iron sulphides, which layers do not occur with that ribbon-like regularity characteristic of many ore bodies in which the mineral matter has been deposited, layer by layer, from solution upon the sides of an open fissure, but of that lenticular form peculiar to schists, while the poorer portions consist more largely of greenstone schist containing only disseminated sulphides. Besides these two forms, as before mentioned, sheet-like lenses of variable size and richness (called shoots) are of common occurrence, forming upon either one of the walls; whilst extending from these into the adjoining wall rock (which is often granite) as well as into the formation itself are disseminations of ore, which apparently indicate that these rich bodies are due to metasomatic action, subsequent to the deposition of the cupriferous dyke.

Exactly under what conditions these were formed it is difficult to determine, since it is usually acknowledged that chalcopyrite is a primary sulphide, whilst these bodies decidedly present all the characteristics common to secondary or replaced deposits.

There are authentic instances in which chalcopyrite has replaced certain organic substances, and since marcasite is commonly of secondary origin there seems to be no reason why it should be necessary to wait until chemists decide the exact reactions that have taken place before a fact can be admitted. That chalcopyrite does occur, both as a secondary as well as a primary mineral. there can be little doubt, since large and rich bodies of this class of ore are usually met with immediately below the secondary sulphides, whereas comparatively lean ore only is often found to immediately follow it as greater

Photo. H. W. B. Talbot. Neg. 411.

Basal beds of the Kundip series, Western Steere River.

depths are reached, or in other words, that the upper portion of a lode, after the so-called primary sulphides are encountered, is invariably richer than the zone below it, although no copper ore other than chalcopyrite be present.

One point of particular interest with regard to secondary enrichment is noticeable upon this field in those lodes which cross the foliation of the rocks, the richer portions in which being apparently governed by the character of the country rock at the point of intersection, thus we find these zones of enrichment tilted upon the fissure plane at an angle coincident with the inclination of the rock folii, which give them a definite shoot-like appearance, whilst the intervening sections in the lode may be either barren or carry only gold values. In some instances the cupriferous sections have appeared to turn off from the main fissure on to the planes of foliation, or to put it the other way round, lodes which at their outcrops appear to follow the foliation of the rocks are found at a depth to swing round on to the main fissure plane, a good instance of which is exhibited in what is known as the "ironcap lode" in the Flag mine, in which the ferruginous gossan outcrop has a course of north-west and south-east, with a dip to the north-east; this at the 70ft. level has a course east and west, with a dip to the south and tilt to the east, *i.e.,* the intersection of the planes. Similar occurrences probably will be met with at one or two other points in the same mine, one of which is called the "eastern leg," but in this case the ore pipe has left the intersection of the planes and followed the foliation to the north-east, whilst the point of intersection of the two could not be examined since it is situated further to the eastward than the present end of the 100ft. level.

It is apparent that a main east and west fissure has intersected a series of normal north-westerly low-grade cupriferous dykes, from which it has been enriched at the point of intersection, and since a considerable portion of the high grade ore that has been obtained from this mine came from veins having a north-westerly course, it is probable that the main lode, the course of which is south of east, is not cupriferous in a primary sense, but has simply been fed at certain definite points called shoots.

As previously stated, a large number of these lodes may more correctly be described as auriferous than cupriferous, owing to the greater value in gold; in some instances, these, as before described, make into copper lodes at a depth with greatly diminished gold values, but there are also a series which lie in the greenstone area to the north-west corner of the map, which although undoubtedly of the same character as the others have proved when the gold practically gave out to carry too low copper values at their lowest levels to be payable.

These lodes are very highly siliceous near the surface, in fact they may be termed quartz reefs or ferruginous quartz reefs, according to the quantity of iron gossan contained. With depth, however,

they assume the usual schistose character, and are often heavily charged with marcasite, and also carry a little copper, whilst deeper still they assume a more basic character, with in places almost a disappearance of quartz. They were worked entirely for gold, some giving very considerable promise when first discovered, but the so-called shoots were short and values fell so rapidly that they are now practically abandoned.

The conclusions drawn are that those cupriferous dykes, which are of sufficient size to warrant deep mining, will prove when the fracture zone is passed to consist entirely of highly basic rock, through which iron and copper sulphides are disseminated, whilst quartz will have almost entirely disappeared and the gold and silver only in practically negligible quantities.

Of the other class of ore body there is little to be said, as they are simply leaching channels which follow the joins in a perfectly kaolinized schistose rock, so altered is this rock that 40 feet were sunk in it by the original prospectors to the vein, under the supposition that it was alluvium. They consist of a belt of kaolinised rock intersected by a series of veins of ferruginous quartz radiating from a main one, the whole of which is often auriferous. They have little inclination, starting from an anticlinal fold, at the apex of which it was small, but very rich stone was obtained at the lower levels. Values are rapidly falling, and will probably shortly become too low to be payable; it is possible, however, that others will be found occupying positions below the ones at present being worked.

PART II.—Description of the Crystalline Rocks of the Phillips River District.

By E. S. Simpson and L. Glauert.

A most varied and interesting series of igneous rocks is represented in the collections of Messrs. Woodward, Montgomery, Blatchford, and Talbot. They range from a normally acid granite through intermediate types to a serpentine, and the study of them is complicated by the large development of hornblende and plagioclase not only in the amphibolites and intermediate rocks but also in the granites, and by the varying texture exhibited by one and the same rock.

GRANITIC ROCKS.

Soda-Granite.—The granite of this district is of an unusual type being almost devoid of orthoclase, the place of which is taken by a soda felspar. Its chemical composition is shown by analyses of [8139] and [8151].

	[8139] Well 25 chs. S. of No. 2 Tank, Ravensthorpe.	[8151] Western Well on W.R. 7517, Ravensthorpe.	Saganaga Lake, Minnesota.
SiO_2	70.27	68.11	69.34
TiO_2	.12	.74	*n. d.*
CO_2	.20	.21	*n. d.*
P_2O_5	.12	.28	*n. d.*
H_2O combined	1.08	.86	1.17
K_2O	.64	.76	.71
Na_2O	4.64	4.58	4.33
CaO	1.76	3.79	3.43
MgO	1.87	1.75	1.18
MnO	.20	.16	*n. d.*
FeO	1.22	2.99	*n. d.*
Fe_2O_3	.97	.11	2.46
Al_2O_3	16.11	15.77	17.25
FeS_2	.09	.17	*n. d.*
H_2O hygroscopic	.10	.11	*n. d.*
	99.39	100.39	99.87
Sp. gr.	2.70	2.74	*n. d.*

The most noticeable features of these analyses are the small percentage of potash and large percentage of soda, and the unusually high percentage of alumina. This latter is interesting as explaining the occurrence of andalusite in the granitic schists. The closest approach to this rock in chemical composition that we can find is the Granite (Amadorose) of Saganaga Lake, Minnesota, the analysis of which is quoted above.

In hand specimens the rock is light grey to dark grey or green in colour, and in texture and appearance varies from that of a typical coarse grained granite [8151] and [8332] to that of a medium or fine grained diorite [8147] and [8318]. In some specimens, notably [1875] and [8147], the hornblende crystals are large and very clearly defined.

Under the microscope quartz is found to be an important constituent in all cases and would appear to be the final product of crystallisation. Plagioclase and deep green hornblende are both very plentiful, the latter largely idiomorphic and evidently the first of the main constituents to crystallise out of the magma. Some ilmenite and biotite occur in nearly all examples, whilst zircon and apatite are seen in some of the sections.

Quartz-Ceratophyre.— Acidic dykes do not appear to be plentiful, but undoubtedly fine grained offshoots from the soda-granite are represented in [8315, 8364, 8553, 7825]. Surface specimens of this rock are pale grey in colour, but a specimen [8553] from a depth of 400 feet in the Mt. Cattlin Mine is very dark grey. It has a specific gravity of 2.68 and contains 71.01 per cent. silica, 0.55 per cent. potash, and 5.36 per cent. soda. These rocks are all very close-grained with occasional phenocrysts of felspar and quartz.

Albite Pegmatite. —Some very interesting specimens of a very coarse-grained pegmatite have been collected. The chief constituent of this rock is albite, both granular and very coarsely crystallised. In places it is of a pale bluish green colour. Some of this mineral with a coarsely lamellar structure was analysed, with the results given below.

Associated with the albite are coarsely crystalline spodumene (see analysis below), pink and green tourmaline, muscovite, lepidolite and quartz. See specimens [1863, 8347, 8487, 8488].

Analyses of Spodumene and Albite.

	Spodumene.	Albite.
SiO_2	61.94	69.13
Al_2O_3	26.48	19.44
FeO	1.82	*Nil*
MnO	trace	trace
CaO	.28	*Nil*
Li_2O	7.02	*Nil*
Na_2O	1.93	10.83
K_2O	.47	.04
H_2O combined	.29	.17
	100.23	99.61
Sp. gr.	3.14	2.63

Two miles south-west of Cocanarup is a pegmatite which is in places a typical graphic intergrowth of felspar and quartz [1855], in others exhibits much muscovite or lepidolite [1859, 1861].

Andalusite Schist.— Two specimens of rock [8463] and [7827] are composed mainly of a fine grained base of sericite in which are embedded numerous crystals of andalusite. These, and a foliated hornstone [8143] largely composed of andalusite, are evidently alteration products of the soda-granites.

Mica-Chlorite Schist.—In places, as the result of the crushing of the soda granite, accompanied by development of sericitic mica at the expense of felspar, and chlorite at the expense of hornblende, we find a mica-chlorite schist formed. See [8311, 8364, 8366, 8567.]

The following are detailed descriptions of some typical sections of these granitic rocks:—

[8151] Sec. 880. Soda-granite, Western Well on W.R. 7517. Coarse grain. Quartz and felspar about equally abundant. Quartz with numerous inclusions mostly "dusty" but some fine spicular, the former under high powers are seen to include minerals and liquids with gas bubbles. Large prisms of apatite are seen in some of the quartz masses. Felspar mostly multiply twinned and much clouded with granular grey matter. Brown biotite is the chief ferro-magnesian mineral, much green hornblende being associated with it. A little ilmenite is present in fine and coarse grains partly altered to leucoxene, also a little pyrites in patches. The ferro-magnesian minerals evidently preceded the felspars in crystallisation, quartz being the last constituent to settle out.

[8139] Sec. 877. Soda-granite, W.R. 4. This is a somewhat darker rock than [8151] and has a coarse texture. White felspar is altogether absent, to the greenish albite no doubt being due the deeper colour of the whole. Although the analysis given above has shown the rock to have a higher percentage of SiO_2 than [8151], the quartz only takes the second place in the micro-section examined, it has a very similar appearance to that in the section just described, except that the stringy arrangement of the enclosures is perhaps more marked. The felspar is cloudy and in this case contains needles and rods of apatite and fragments of hornblende, it shows some fine examples of the usual repeated twinning on the Albite plan. The strongly pleochroic hornblende needs no remarks except that it is very full of enclosures and has a very ragged outline. Ilmenite is present in fair abundance. Order of crystallisation evidently the same as in [8151].

[8147] Sec. 876. Soda-granite, near W.R. 7607. A coarse-grained rock similar to the preceding but much darker owing to the large development of hornblende. This is the most prominent constituent; there is a fair amount of felspar and some quartz. Under the microscope felspar and hornblende are seen to form the main mass of the rock, the former is idiomorphic as regards the quartz, cloudy owing to alteration and mainly composed of the plagioclase variety. The hornblende is very brilliant, generally

green or yellow according to the section's direction; at times it is brown owing to iron staining and in many cases gives splendid examples of twinning parallel to the orthopinacoid. The quartz is well represented and in some instances, besides the usual style of enclosures noted in the other sections, mica (biotite), ilmenite (leucoxene), and zircon are present, also fine needles of rutile or tourmaline similar to those noted in [8151].

[1875] Sec. 106. Soda-granite, three miles west of Mt. Desmond. This is slightly different in appearance to any previously described. It is coarse grained with much white felspar and some clear quartz, in which are imbedded numerous well defined long and somewhat narrow crystals of hornblende. Under the microscope the allotriomorphic character of the quartz is very evident. Crystals of apatite are not seen, but on the other hand many fine, long, slender needles of a dark brown mineral (tourmaline or rutile?) are found besides the usual small enclosures of minerals, liquids, and gases. Plagioclase is the chief felspar and often shows repeated twinning and large patches of decomposition products. Deep brilliant green hornblende is very abundant being represented by large well defined crystals, frequently twinned, and enclosing somewhat numerous grains of iron ore and rods of rutile, generally arranged along the cleavage lines. A little pale secondary hornblende is present as also a little biotite in places.

[8152] Sec. 881. Soda-granite, near W.R. 8358. A somewhat finer grained rock than any of the previous ones, in which pale grey felspar is the most prominent constituent. Small crystals of hornblende are very uniformly distributed. Under the microscope the chief constituent is seen to be felspar, much clouded and, for the most part, devoid of twinning. It contains numerous enclosures of apatite. The quartz which is abont equally abundant contains dusty and fine spicular enclosures. Green and brown biotite is common, sometimes intergrown with muscovite. Dark green hornblende is abundant in coarse crystals, with a little ilmenite. Occasional crystals of zircon are seen.

[8318] Sec. 904. Soda-granite, W. R. 7385. A fine grained grey rock. Much clouded felspar, devoid of twinning, forms the greater part of the rock. Quartz and hornblende both abundant. The quartz contains numerous enclosures, apatite, rutile (tourmaline?), hornblende and zircon are recognisable. Also liquid and gas inclusions, the cavities sometimes taking the form of negative crystals. Some ilmenite partly altered to leucoxene.

[8310] Sec. 900. Altered Soda-granite, M.L. 236, Oversight Extended. A fine grained massive rock. Under the microscope cloudy patches of felspar are still visible, though boundaries are very ill defined and the usual interference effects barely distinguishable. Finely granular quartz, hornblende, biotite, ilmenite and epidote make up the balance of the rock which is inclined to be slightly gneissic in structure.

[8553] Sec. 935. Quartz Ceratophyre, 400ft. level, Mt. Cattlin C.M. Dark grey, very fine grained, massive rock, with visible phenocrysts of quartz and felspar. Specific gravity of 2.68. Contains silica, 71.01 per cent.; potash, 0.55 per cent.; soda, 5.36 per cent. Under the microscope the rock is seen to consist of a fine grained crystalline ground mass of felspar (albite), biotite and quartz, in which are embedded numerous phenocrysts of cloudy felspar, mostly if not wholly plagioclase. Brown biotite occurs somewhat freely in phenocrysts. A greenish chlorite, some epidote and a few crystals of zircon are seen. Though quartz phenocrysts are not uncommon on the faces of hand specimens, none were included in the section examined.

[8463] Sec. 914. Andalusite Rock. Sunset Mine. This is a greyish sericitic rock showing many fine large crystals of flesh-coloured or pink andalusite. By the aid of the microscope we see that it is essentially composed of a sericitic ground mass containing fine porphyritic crystals of andalusite and some smaller ones of phlogopite or some allied mica. Many small masses of secondary quartz as well as small crystals of rutile and ilmenite and other unimportant assessories are easily to be distinguished.

[8143] Secs. 873 A to F. Andalusite Rock and Schist (Hornstone). Near M.H.L. 126, Ravensthorpe. This specimen is of exceptional interest in that it consists of an andalusite rock, similar to the above, a portion of which has been so crushed and squeezed that not only a schistose but also an ''augen'' structure has been superinduced. Six sections heve been made of this rock, both in the crushed and the uncrushed portions. In the latter as in [8463] we see numerous large and small phenocrysts of andalusite full of various enclosures, amongst which were recognised tourmaline magnetite and long slender needles that may be tourmaline but which are too slender to be determined with certainty. Smaller crystals of felspar, tourmaline and biotite are also present in a ground mass composed essentially of sericitic or chloritic material.

The crushed and altered portion shows the same constituents. which have been so much affected that they have assumed a flow structure, the large crystals, even the hard andalusite, being crushed and squeezed out of shape in a most remarkable manner.

[8311] Sec. 901. Mica-chlorite Schist. Near shaft of M.L. 236, Oversight Extended.

This is a greyish green rock having a schistose structure and a somewhat silvery sheen due to the small flakes of chloritic and sericitic material present. The microscope shows that the rock is an altered acid rock. We have a fair amount of quartz showing ''strain figures'' in a matrix composed of sericitic, felsphatic and chloritic material, the latter being most plentiful in those places where small crystals of rutile and iron ore indicate the former presence of ferro-magnesian minerals.

[8567] Sec. 969. Mica-chlorite Schist. Mount Desmond Mine.
The general appearance of this rock is similar to the above in every way. Microscopical examination shows that here again the main mass of the rock consists of chloritic and sericitic material in small scaly masses, in this are many irregular pieces of quartz which on further examination are seen to consist of numerous fragments, the general appearance of which suggests a secondary origin. In places the rock is quite green owing to the great abundance of chlorite, and here again we find an abundance of rutile crystals (prisms, etc.) as evidence of the former presence of a ferro-magnesian mineral. Several hexagonal crystals of zircon are to be seen, being the prism with its two pyramids. Iron ores are also present, particularly in those portions of the field where the rutile crystals are most abundant.

ROCKS OF INTERMEDIATE BASICITY.

Large areas of "greenstones" of intermediate basicity, partly massive and partly schistose, are shown on the map, and associated in part with them several more or less distinct types of dykes, including (*a.*) Quartz diorites of two types, (*b.*) Diorites characterised by a very large preponderance of primary hornblende, (*c.*) Diabases in which the chief ferro-magnesian mineral is fresh or altered augite, (*d.*) Lamprophyres (Kersantites) in which the chief basic mineral is biotite.

Amphibolite.—One mile nor-nor-west of Mt. Desmond, close to the limits of the map, is a rock [8322], which appears to the eye to be composed wholly of very large crystals, of a somewhat light green amphibole. It is distinct in appearance from any rock within the area mapped, except perhaps [8468], and resembles some of the amphibolites of Kalgoorlie and elsewhere on the goldfields. Like them, it appears to be an altered pyroxene rock. (*See* "Serpentines."

Massive Diorite Rocks and Camptonites.—From the main mass of greenstone in the Northern part of the field come two types of rock—1st, a dark green massive rock, somewhat coarse-grained and seen under the microscope to consist almost entirely of deep green, well-crystallised hornblende, with a little interstital quartz and clear felspar [8465, 8469]. 2nd, a light to dark green rock, which, under the microscope, is seen to be fine grained, with a fine granular base of felspar, iron ore and usually quartz in which are embedded numerous small, and some large crystals of green or colourless hornblende [7826, 8145, 8388, 8464]. The structure of these dykes differs considerably from that of typical diorites, and partly because of their structure, partly because of their affinities with the kersantites, they are provisionally classed as camptonites. Biotite occurs in both types in variable amount.

Diorite Dyke Rocks with much Hornblende.—A number of dykes are composed of a rock which is almost wholly hornblende, the colouring of which is very distinctive, viz., rich blue green,

strong green and pale yellow [8140, 8141]. The interstital matter is mainly felspar and the rocks are either coarse or fine grained.

Quartz Diorite Dykes.—These differ somewhat amongst themselves, both in texture and composition, some being barely distinguishable from the previous mentioned rocks except for the quartz, the hornblende being very plentiful and of the same type as in the last group. Other specimens exhibit much quartz, whilst the hornblende is subordinate to the plagioclase. The hornblende in some tends to gather round nuclei, forming bunches 5 or 6 m.m. in diameter, and distant about 10 m.m. apart, and in these rocks chalcedony is somewhat freely developed [8149, 8317, 8327, 8359].

Enstatite Diabase.—A single example occurs of a very fresh coarse grained rock [8144] composed of clear multiply twinned felspar and augite, with subordinate hornblende, enstatite, ilmenite and quartz. A fine grained weathered rock [6052], consists largely of serpentine, with a structure which would suggest a pyroxene as the original mineral from which it is derived.

Kersantite.—In the Elverdton mine and its immediate vicinity, there is a fine grained dark coloured dyke rock, composed of a granular mixture of clear felspar and biotite, with a little hornblende and quartz [8462, 7822, 7912]. The silica percentage in a typical example [8462] was found to be 59 and the specific gravity 2.81.

Biotite Schist.—Biotite appears to develop readily at the expense of hornblende in all these rocks of intermediate basicity, giving rise ultimately to biotite schists [1895, 1907]. Examples occur at Ravensthorpe, Mt. Desmond and Kundip, and show all the features characteristic of pressure metamorphism.

Garnetiferous Schist and Eclogite.—A number of examples of greenstone schist are characterised by the occurrence of a garnet which, where determined, has proved to be grossularite. One such rock [8155], the chief constituents of which were green hornblende and plagioclase with subordinate iron ore, garnet, and quartz, has the following composition:—

SiO_2	62.23
TiO_2	1.51
CO_2	.23
P_2O_5	.28
H_2O combined	.34
K_2O	.29
Na_2O	1.47
CaO	6.16
MgO	4.09
MnO	.56
FeO	10.46
Fe_2O_3	.08
Al_2O_3	11.90
FeS_2	.79
H_2O hygroscopic	.07
	100.45
Sp. Gr.	2.96

Biotite is very freely developed in some of these rocks at the expense of the hornblende [**1906, 8533**], the schistosity of the rock being usually in direct ratio to the proportion of biotite present. The hornblende varies from almost colourless to dark green. The proportion of garnet present is very variable, but in all cases it appears to be a late development, as it encloses numerous fragments of the other minerals.

Chlorite Schist.—This does not appear to be a common rock on the field, but examples of it are present in the collection [**8311, 8366**]. They are evidently altered hornblende rocks.

The following are detailed descriptions of such of these rocks as have been examined in detail:—

[**8322**] Sec. 948. Amphibolite, one mile N.N.E. of Mt. Desmond. This is a greyish green rock showing large lath-shaped crystals of hornblende of irregular outline, some of them being as much as 30 m.m. in length. The whole rock has an altered appearance and suggests the presence of a good deal of chloritic material. The microscopical examination shows that the alterations typical of pyroxene rocks are very far advanced. We get no felspar, but just a mass of aluminous hornblende, altering pyroxene and chloritic or serpentinous material. Needles of tremolite are very common in the amphibole masses. (See Serpentines [**8154, 8326**]).

[**8144**] Enstatite Diabase, W.R. 7517, and

[**8568**] Enstatite Diabase, Mt. Desmond Mine.. Though these two dyke rocks were obtained some distance apart they resemble one another very closely though [**8144**] seems somewhat fresher. The hand specimens show a medium grained dark blue or dark green rock with many bright faces of angite crystals, the whole being mottled through the presence of whitish masses and lath-shaped crystals of plagioclase. Traces of pyrites are also to be seen. Under the microscope the chief constituent is seen to be pyroxene. We have it in two habits, in some places an "ophitic" structure is developed whilst in other the augite takes the form of small granules. The mineral shows good examples of twinning, and often exhibits the characteristic cleavages of the group. Further examination shows that there is a rhombic-pyroxene as well as the monoclinic augite, and this, on account of its straight extinction, its almost total lack of colour and very weak pleochroism as well as its highly developed cleavage has been classed as Enstatite.

In [**8144**] some fine masses or crystals of this mineral are to be seen, one piece in particular being interesting, as it shows the decomposition gradually encroaching upon the whole mass; near the centre the mineral is still very fresh, but as the edge is approached chloritic material is seen to fill the cracks or cleavage lines, coming more and more in evidence, till at the extremity all the pyroxene has disappeared and we have simply a mass of

greenish and brownish chlorite adopting a rudely spherulitic structure, portion of which might be taken for serpentine.

Though twins of enstatite are rare, one was seen in [**8568**], in which the twinning was along one of the cleavage planes.

In [**6052**], from the Last Chance Mine, the enstatite and augite are more difficult to separate on account of the small size of the crystals, for in this rock as well as [**8568**] the ophitic structure has disappeared, and the whole of the pyroxenes are granular.

In thin sections the augite has very little colour and gives practically no pleochroic colours, but with the crossed nicols bright colour effects are obtained as well as unmistakable evidence of twinning.

Taken on the whole the mineral is very fresh, those alterations that have taken place being confined to certain portions of the slide. At the same time good instances can be seen, especially in the more coarse-grained examples, of the mineral altering into chloritic material; it being in some cases completely converted into spherulitic aggregates of chlorite which send out tongues into the surrounding felspar by means of the cracks and cleavage lines. In other examples every step in the transition from pyroxene to hornblende and biotite can be traced, the alteration even extending beyond this into a green chloritic material similar to that just referred to. Another alteration product of the ferro-magnesian minerals and the felspar may be noted here, it is Epidote which is to be seen in [**8568**] and [**6052**] usually taking the form of irregular yellowish grains showing slight pleochroism and bright colours with the aid of crossed nicols.

The plagioclase felspar of the rocks is very conspicuous, forming fine idiomorphic lath-shaped crystals which give fine examples of twinning on the Albite plan. The mineral is very fresh and clear, only occasionally showing signs of saussuritisation. Upon measuring the extinction angles of the twins it is found that in almost every case the mineral was well within the labradorite margin, 30 degrees or over. Quartz is also present as an original constituent as is shown by its micro-pegmatitic intergrowth with felspar in several of the slides examined [**8144**]and [**8568**]. Interstitial masses and grains are also present, and show by their outline that they were formed late on in the course of crystallisation, some of the masses may even be secondary, but that does not seem likely in this group of the Phillips River rocks. Apatite is a common inclusion. Titaniferous iron ore is also to be seen as an original constituent; some of the crystals, being in close conjunction with altered or altering ferro-magnesian minerals, are without doubt of secondary origin. The undoubted secondary minerals, chlorite, biotite, hornblende, epidote and serpentinous matter, have already been mentioned in passing. The most important one is hornblende; from its associations with the augite there is no doubt that this is purely secondary, for all the steps can be seen between

the unaltered augite to the fresh green hornblende with its clear colours, its fine cleavages, and in many cases its almost perfect outline.

Biotite both green and brown in colour is often associated with the hornblende as an alteration product, it is very fresh and shows few signs of decomposition, except for the presence of chloritic matter at the fibrous extremities of some of the masses.

[8140] Altered Diabase, near M.H.L. 16. This is a dark blue or blue black dyke rock showing many bright cleavage surfaces of hornblende. With the microscope it is seen that the rock is practically a mass of ferro-magnesian minerals and their alteration products, we see hornblende in large masses showing many twinned individuals giving fine examples of prismatic and basal cleavages, good pleochroism and very bright polarisation colours:—

$\mathfrak{a}$ = Straw yellow.
$\mathfrak{b}$ = Yellowish green.
$\mathfrak{c}$ = Blue green.

Its structure and form suggest that it is of secondary origin Some of the masses are altering and passing into green chloritic material. Enstatite is present. Plagioclase felspar is represented by a few odd lath-shaped crystals. A little epidote seen, a grain or two at the most.

This rock is evidently very poor in felspar, and is either derived from a similar diabase or the felspar has disappeared entirely, being replaced by aluminous hornblende and chlorite.

[8328] Altered Diabase, near M.H.L. 67. In this the stages of alteration are further advanced, although some felspar (?) is present. It is a grey rock with yellowish patches and appears to consist entirely of hornblende, augite, and decomposition products (bastite, etc.).

Under the microscope we see that the main mass of the rock consists of chloritic and serpentinous material, imbedded in which are the remnants of many of the original minerals, the enstatite is converted into bastite, and the augite is present in very much more corroded masses than in [8322]. Felspar is represented by ill-defined and much clouded masses and patches, generally limited in extent and too impure to allow a determination of the group to be made. Iron ores are present in the form of grains and crystals, the former often filling veins penetrating the mass. In some parts, too, the ferruginous material has stained the adjacent minerals and alteration products.

Secondary hornblende giving bright polarisation colours and showing characteristic cleavage is not rare, generally it is very pale-coloured and fibrous, the needles often resembling tremolite. The rock is a serpentinous rock with bastite, and is clearly an altered form of an enstatite diabase.

[8317] Sec. 903. Quartz diorite with chalcedony, W.R. 7385. This is typical of this well-defined type of dyke rock which in-

cludes also [8149, 8327, 8359]. Plagioclase felspar is the chief constituent, its habit is usually lath-shaped crystals of rectangular outline, and in this group of rocks it is evident that in the majority of instances it is idiomorphic. On the other hand fields are seen in all the sections examined that give good examples of micro-pegmatitic intergrowths with quartz. As regards its structure, the felspar is very much altered, being almost entirely converted into saussurite from the centre outwards to the edges of the crystals. Sufficient evidence was, however, on hand to determine the presence of repeated twinning on the albite plan in the original unaltered mineral, this was seen to the best advantage in [8149, 8317]. Owing to the state of alteration of all the crystals it is impossible to say whether the mineral contained enclosures in its original state, the masses as now seen give no evidence of this. In some sections part of the slides show the presence of hornblende fibres and chloritic matter in the forms of granules and fibres as an alteration product of the rock. The quartz of this group is present in the usual irregular masses so much associated with the granites, and, as already mentioned, in micropegmatitic intergrowth with plagioclase felspar. The mineral, when compared with samples from other rocks, is very free from inclusions. When these are present they generally take the form of long narrow needles which show up in high relief (rutile or tourmaline), or are present as prisms and hexagons of apatite. Zircon was also seen in a similar rock [8149]. Silica is also present in a cryptocrystalline condition, and is a very distinctive feature of this group. Every slide gives good examples of radiating tufts and spherular aggregates of chalcedony usually associated with the quartz and in [8149] seemingly a decomposition product of the felspar.

The identity of the original ferro-magnesian mineral is a matter of some doubt, owing to the amount of alteration that has gone on since the rock was formed. An examination of all the sections shows that whereas its relationship to the felspar is distinctly allotriomorphic it is difficult to say how it stands with reference to the quartz on account of alterations that have taken place.

Some of the sections suggest augite in the long lath-shaped crystals so often associated with trachytes, and this is most likely the original mineral of this group. Whatever the primary mineral was, it has now quite disappeared, and in its place we usually get a greenish yellow or greenish hornblende with the characteristic habit and cleavages of the mineral, greenish chlorite and chloritic material and biotite.

The outward appearance of this rock suggests much altered hornblende, and the microscopic section proves its truth. Here we see practically none of the original mineral, its place being entirely taken up by secondary hornblende, altering hornblende, chloritic material and chlorite. This latter product can here be studied to

great advantage, every step of the change can be viewed, and it is seen to be much more complete than was shown in any of the other sections, the coating of the felspar crystals, the penetration of the chlorite and the alteration of the adjacent felspar into epidote is most apparent. Ilmenite and leucoxene are abundantly associated with the hornblende, etc., in this section.

[8149] Sec. 879. This is a medium-grained greyish rock consisting of felspar, quartz, and hornblende, with numerous segregations of the latter mineral, 5 or 6 m.m. in diameter and rarely more than 10 m.m. apart. The chief constituent is seen to be plagioclase, showing a tendency to form lath-shaped crystals and giving some examples of repeated twinning. Quartz is very plentiful and appears to have been the last mineral to crystallise out, it is clear, contains few inclusions, chiefly minerals (? apatite, etc.). Hornblende is scattered throughout the section, it is rather altered and iron-stained, has a greenish yellow hue, and is darker near the edge. There is a good deal of titaniferous iron present in the rock. Zircon, apatite, epidote, and chalcedony present as secondary minerals. A little fresh, clear, and bright secondary hornblende is to be seen at the edge of some weathered masses of the same mineral.

[8327] Sec. 907. Quartz Diorite near Elverdton Dam. This is a mottled rock of medium grain composed of masses of dark green or blue hornblende and white or greenish plagioclase. Under the microscope the rock is seen to consist of plagioclase, hornblende, and quartz with ilmenite (leucoxene) and apatite. As alteration products or secondary minerals may be mentioned epidote, chalcedony, secondary hornblende and chlorite. Plagioclase is present as the chief constituent, and it is very cloudy, so that it does not give good polarisation reactions, still its outline is very distinct, and suggests this mineral rather than orthoclase. It often contains small inclusions of the ferro-magnesian minerals present in the rock. Hornblende is present in two ages, the one brownish in colour and much iron-stained is idiomorphic and is fairly plentiful. In places it is changing into a bright green and fresh-looking hornblende, the nature of which can easily be determined on examining crystals placed adjacent to quartz and felspar. Quartz is very nearly as plentiful as the original hornblende. It contains numerous inclusions consisting of apatite, etc. Associated with it are many masses of chalcedony. A fair amount of ilmenite, changing into leucoxene, also epidote, chlorite, apatite, and zircon are present.

[8359] Sec. 910. Quartz Diorite. 25 chains N.W. of N.W. corner of G.M.L. 101, Ard Patrick. This is a medium-grained granitic rock, the chief constituents being white plagioclase felspar, at times inclined to be greenish in hue, and dark green hornblende which is generally in lath-shaped crystals. A little quartz could also be recognised by the aid of a lens.

Under the microscope cloudy twinned and untwinned felspar is seen to be the predominating constituent; its usual tendency is to crystallise out in long rectangular crystals, but in some portions of the slide a fine micro-pegmatitic intergrowth with quartz is seen, in others there is not the slightest doubt that the felspar is idiomorphic as regards the hornblende. The mineral is very cloudy and contains many inclusions of hornblende and chlorite.

The hornblende is present in two ages, the original mineral is brownish in colour and only slightly pleochroic, whilst its effect upon light with crossed nichols is not very marked. The secondary mineral, however, is a bright green, and gives bright colours and shows intenser pleochroism.

The older mineral is much altered, and is associated with a number of fine ilmenite crystals, and may have been formed before the felspar. The quartz is present in fairly large crystals and interstitially. On the whole it is very clear and free from inclusions, though a fair number of apatite rods are to be seen. Its micro-pegmatitic intergrowth with felspar has already been noted. A little brown biotite is seen and some chalcedony may be present.

This will be a quartz diorite rather more basic than [**8149, 8317, 8327**]. Chalcedony appears to be present; a little was seen but it was so limited in extent that it could not be seen to advantage.

[**8316**] Sec. 923. Quartz diorite. Near S.W. corner of G.M.L. 132, Darley. This is a medium-grained rock of a granitic type, it differs from all the other specimens from the district in the presence of pink felspar, the other components are hornblende and plagioclase, the ferro-magnesian mineral being slightly porphyritic.

Under the microscope the porphyritic structure is accentuated and it is seen that plagioclase is present in lath-shaped crystals and in smaller masses, being in fact the chief constituent. The rock is fairly fresh, and in consequence we get good polarisation results when compared with the other quartz diorites. In places micro-pegmatitic intergrowth with quartz is to be seen. Twins very common, giving an angle of 15 degrees (oligoclase-andesine).

The quartz is fairly abundant in small sized grains, and in larger masses, where it is associated with the felspar, it resembles the quartz of the other classes of rocks examined, in the presence of needles of rutile (or tourmaline) and prisms of apatite as inclusions, besides more minute crystalline matter that could not be identified. The ferro-magnesian constituent presents interesting features. The original mineral has become greatly changed; in places it is still present as a green hornblende, but as a rule it has become disintegrated, has altered into epidote and secondary hornblende, which is very fresh, and shows the characteristic cleavages, or has given rise to greenish chloritic material which

has spread into the adjacent minerals. The relationship between the felspar and the hornblende was difficult to ascertain on account of the alteration subsequent to crystallisation, but it is safe to assume that here again the felspar is idiomorphic, whereas the quartz is interstitial where not intergrown with the felspar. Ilmenite and leucoxene are present as accessories, and show their usual features, including skeleton crystals. Apatite is present in some fine large prisms. Biotite is to be seen in the masses of alteration products resulting from the decomposition of the original ferro-magnesian mass. There seems no doubt that some of the iron ores are the result of the same process of alteration.

[**8148**] Sec. 878. Quartz diorite, near M.L. 248, Red Hill. This is a medium-grained rock with white crystals of felspar and dark green hornblende in one part, whilst in the other portion the texture is finer and there are no large crystals. On one side of the specimen a layer or band of biotite covers nearly the whole surface, showing that the rock has been subject to a considerable amount of metamorphic action. The micro. section examined shows both the fine and coarse-grained rock. In the latter portion we find that altering plagioclase and secondary felspar (albite) are the chief constituents; the former is so much altered that the polarisation effects are quite obscured, and no determination is possible. The albite on the other hand is quite clear and fresh, and gives good opportunities of measuring the extinction angle—16 degrees.

The hornblende is very fibrous in its structure, but gives fine polarisation colours and quite distinct pleochroism. There is a good deal of iron ore present in the form of ilmenite, which by its relationship with the hornblende suggests very forcibly that both these minerals are the resultants of metamorphic action upon the original ferro-magnesian mineral, which contained much more iron than the present fibrous hornblende. Apatite is present as an original, whilst chlorite and biotite (enclosing lenses of quartz) and quartz are present as secondary minerals, though some of the last-named may be original.

In the more fine-grained portions we have the same minerals, but here they are all uniform in size, and we have a greater amount of secondary quartz and albite. The brown bleaching biotite is also much more abundant, the whole fine-grained mass reminding one very much of the Kersantites, though the colour of the biotite is not identical. In this rock the form of the hornblende is the most noticeable feature, for this variety is only rarely met with among the other rocks examined. We generally get a weathered or altering hornblende giving somewhat anomolous colours and a fresh secondary form in which—

$\mathfrak{a}$ = straw yellow.
$\mathfrak{b}$ = dark green.
$\mathfrak{c}$ = blue green.

These colours do not agree with those given by the fibrous form

present in [**8148**], which reads very pale straw, green and pale blue.

Among this group of quartz diorite rocks there are several specimens which are much finer in structure; these are [**8141, 8313**, etc.], which will now be described. the latter shows white or pale patches which look like somewhat altered or weathered felspar, as [**8141**]. This, which we take to be the better sample, will be gone into first.

It is a blue-black compact rock showing nothing but hornblende crystals to the naked eye. By the aid of the microscope it is seen to consist of green or greenish hornblende usually in the form of fibrous masses somewhat similar to [**8148**], but not differing so much from the usual run of hornblende met with in the diorites. Under the microscope the general type of the rock is very like the diorites just described. the felspar (plagioclase) is present in idiomorphic crystals all much altered and in irregular masses. Some of them show signs of twinning and give polarisation colours, but not of sufficient value to enable the group of the felspars to be diagnosed. Albite, however, is present. The hornblende is very similar to that described before, and from its freshness is probably secondary. Very little quartz is present. and that which is to be seen is interstitial and secondary. No accessory minerals are recognisable in this rock. Among the chief constituents the hornblende is by far the most important. and is remarkable for the presence of small needles which are forcing their way into the felspar on every hand.

[**8313**] has already been described as regards the hand specimen. The micro slide shows the rock to be more altered than the preceding. The hornblende is very fresh and gives some splendid examples of basal and prismatic cleavages and twins, whilst all the masses give good pleochroism and polarisation colours. The felspar, which is taken to have been a plagioclase, is much altered, some masses being completely altered into saussurite, not a single mass being fresh enough to allow the determination as to group to be undertaken with success. The quartz is clear and contains fine prisms of apatite, but few other inclusions. Suggestions of micro-pegmatitic intergrowth with felspar are to be seen here and there. Ilmenite is present as skeleton crystals, and is evidently in part, if not wholly, an alteration product derived from the original ferro-magnesian mineral. Sphene and biotite are also to be seen as well as a little epidote.

[**8565**] This fine-grained rock is somewhat darker in colour, but its essential points agree with the two previous rocks. With the microscope we see that it consists of much altered felspar (saussurite) and green hornblende and chloritic material. The hornblende is much changed, and only in rare intervals gives good or fairly good polarisation results. Most of the ferro-magnesian mineral has undergone a great deal of change, and has even gone

as far as to be partially converted into chlorite. Secondary albite and quartz are abundant, filling up all the cavities between the larger masses of minerals. Here we evidently have to deal with a diorite that is very highly altered, indeed, perhaps more so than any other of the series; a rock, too, which may be found to be a connecting link between this group and the so-called ''Camptonites'' which are to be described later on.

[8465, etc.] Camptonites. These rocks are all fine grained, and of a grey-blue or grey-green colour. As a rule they show no definite crystals, though traces of cleavage faces and crystal faces can easily be seen even with the naked eye. The constituents are chiefly hornblende, which is present in large crystals of a secondary nature [7826, etc.] or in smaller crystals and grains [7825, 8465] that at times can scarcely be termed porphyritic. The felspar is sometimes represented by weathered porphyritic original crystals, but generally is only seen as one of the component parts of an albite quartz matrix or mosaic. Accessory minerals in the form of iron ores, etc., are to be seen. As the structure of some of these differs from the true camptonite type it has been thought necessary to draw attention to the fact before proceeding further.

The rocks themselves too show a diversity of structure generally however of a purely secondary nature. Roughly speaking, they may be divided into two or three classes. We have the series [8465, etc.], which show the following micro structure:—

The hornblende is very abundant, consisting of green and yellowish masses and lath-shaped crystals scattered promiscuously throughout the mass and adopting a rudely aggregated structure. Its general appearance is very characteristic, these remarks refer not only to its shape or form but also to its pleochroism and polarisation effects. The felspar as already mentioned is practically confined to the ground mass where it and quartz form a very fine grained mosaic so characteristic of secondary albite. Some of the sections, particularly [7825], show the remains of large twinning porphyritic crystals of plagioclase, which are much altered and full of needles and prisms of green hornblende. Brown biotite and epidote are also to be seen as secondary minerals.

In most of these sections we find small grains of iron ores (ilmenite, etc.), scattered all over the field. These it seems are the result of the alteration of the original ferro-magnesian mineral altering into a less iron-bearing form.

[8319] is a very similar rock to all the above, but shows signs of incipient schistosity in the parallel arrangement of the smaller hornblende prisms.

[8325] is a rock very similar to this group of Camptonites. We have the albite mosaic and grains of iron ores and the usual hornblende, this latter however seems to be altering into long, clear, colourless prisms or needles that may be an amphibole, but which are difficult to determine with certainty; the whole rock is very cloudy and is evidently altered and weathered.

The second class of Camptonites differs from the first in the presence of many long, clear hornblende crystals which seem to be forming out of and on the smaller masses of the earlier generation.

[7826] shows the albite mosaic and the grains of iron ore in their characteristic forms as noted in the earlier Camptonites. The hornblende, however, is different, the earlier generation is present in small fragments of a brownish hue, but are almost pushed out of existence by the many masses of the later amphibole. This is seen in long ragged masses and well defined crystals giving good cleavage lines and very characteristic pleochroism and polarisation results. Many fine twins are to be seen. Quartz is present in conjunction with the albite, copper pyrites fairly abundant, apatite seen. Biotite may also be present but is not easy to determine in this specimen.

[8145] is very similar to the preceding, the biotite is easily recognised whilst the remains of porphyritic felspar crystals are very prominent. A little apatite is also noticeable in long, slender rods.

The next three rocks, though they resemble the preceding to a great extent, have some features in common with the Kersantites, for instance, brown hornblende and biotite are becoming more prominent, so much so in fact that it is a matter of doubt whether they might not just as well be classed as Kersantites, which practically only differ from Camptonites in a greater percentage of biotite and a smaller amount of hornblende.

In this district, at any rate, the main features of the two groups and their constituent minerals only vary in their relative abundance in the main masses of the rocks. The biotite is not produced by pressure for no signs of schistosity can be seen on any of the specimens.

[8560] contains the remains of phenocrysts of plagioclase now converted into albite, a much greater abundance of hornblende and a good deal of ilmenite, giving some fine skeleton crystals. As before stated, all the minerals are very clear and look exceedingly fresh.

[8561] similar to the above, but with rather finer grained hornblende, more brown hornblende and biotite and altering felspar forming albite and quartz and sericite (?).

[8469] is practically an amphibole rock with a little interstitial albite quartz and iron ore. Even in the hand specimen the mass is bristling with crystals of hornblende showing their bright and glistening cleavage faces.

The "Camptonites" appear to pass by insensible degrees into typical Kersantite dykes, members of the former group being known with less hornblende and considerable biotite and of the latter group with much hornblende in addition to much biotite.

[7912] Sec. 947, Kersantite. 300 feet Mt. Cattlin Mine. This rock bears a great resemblance to [8469] the only noticeable difference being a greater proportion of felspar apparent to the eye; the presence of more veins and the presence in them of quartz and felspar.

Under the microscope it is seen at once that we are dealing with a different type of rock, whereas bluish green, green, yellowish green hornblendes are still the chief constituents as in [8469], the percentage of biotite has risen considerably. This ferro-magnesian mineral bears the same relationship to the hornblende as in the other rock, similar phenomena being noticed. Again there is a greater amount of weathered felspar and interstitial albite, together with the occurrence of rather more quartz and mica. From these facts it would not be indefensible to class this rock as a type intermediate between Camptonites and Kersantites.

The specimen examined is not very fresh, the hornblende has lost some of its clearness, the felspar (excepting the secondary albite) is very cloudy and the mica shows lenticular enclosures which in some cases are possibly calcite and in others (giving lower polarisation colours) are undoubtedly quartz. This biotite also shows signs of altering into a green decomposition product.

[8557] is very similar to the above, the minerals are smaller. The quartz is more equally distributed throughout the rock and augite is represented by a few small grains.

[7823] shows all the essential features of the above. Chloritic decomposition products are associated with the biotite and octahedra of magnetite make their appearance. Two porphyritic crystals of quartz are to be seen in the section round which the other constituents (chiefly the biotite) have formed themselves in a manner which suggest "flow structure" or "augen structure."

[8466] shows a general structure similar to the preceding but differs in the greater abundance of small laths of green hornblende and numerous octahedra of magnetite.

[8467] from a neighbouring mine shows much more olive brown biotite and less hornblende and has no quartz phenocrysts.

[7822] is like the preceding but contains two altering plagioclase crystals which are porphyritic.

[8462] is similar to the above showing a few quartz phenocrysts as well as the plagioclase.

[8468]. In this we have a rock very like some of the Camptonites as well as the Kersantites. In a ground mass consisting of a mosaic of albite, green prisms, rods, or laths of hornblende, etc., we have large porphyritic crystals of corroded biotite being altered into long fibrous crystals of a clear and colourless hornblende which gives fine colours and in places shows the characteristic cleavage. To increase the resemblance a fair amount of ilmenite and pyrites is scattered throughout the rock.

This will be an intermediate type which bears a greater resemblance to Kersantites just as [**8560, 8561, 8469**] swing towards the Camptonites.

[**8155**] Sec. 883, Hornblende-Eclogite. Ravensthorpe Range, east of Ravensthorpe. An analysis of this rock is given on page 27.

Microscopical examination shows a fair number of small pale pink garnets full of inclusions of the matrix, in a schistose mass of fine grained quartz, albite, hornblende, the latter often showing a tendency to form radiating tufts. A few larger phenocrysts of primary quartz and very cloudy lath shaped felspars are present. Ilmenite is abundant, a few grains of epidote, bright yellow in colour, are also to be seen. This is an altered rock of intermediate composition.

[**1911**]. This is very similar to the above, but contains numerous garnets and is rather darker in colour. The micro-section shows many pale clear garnets and a few large crystals of quartz and felspar in a matrix of quartz, albite and hornblende, the latter as in [**8155**] being very abundant. This is most likely a portion of the same rock altered in a similar way.

[**1883**] is similar to the preceding but paler in colour. Microscopical examination shows fine clear pink garnets full of enclosures and pale fibrous hornblende in a matrix of quartz albite and hornblende with countless grains of ilmenite bearing a great resemblance to some of the so-called "Camptonites."

[**8533**] is micaceous and schistose and is best termed a Garnetiferous biotite schist, the garnets are very numerous and of large size.

[**1906**] is very similar but has much smaller and fewer garnets.

ULTRABASIC ROCKS.

Serpentine.—The most basic class of igneous rocks is represented by an intrusion now all converted into Serpentine. On the surface this weathers largely into magnesite.

[**8154**] Sec. 882, Serpentine, ½ mile W.N.W. of the Last Chance mine. This is a mottled dark blue and greenish rock consisting of patches of green material in a dark blue base. Traces of a crystalline structure can be seen particularly at one edge of the specimen. The whole rock has a serpentinous appearance. Under the microscope the rock shows much green serpentine, as well as the remains of felspar crystals. From the structure of the former and the distribution of the magnetite it seems probable that the original rock was an olivine gabbro.

[**8326**] Sec. 924. Serpentine, 2 miles S. of M.L. 266. A blue black rock with yellowish-green patches. Under the microscope the rock is seen to be an almost pure serpentine with mesh structure and minutely fibrous. A fair amount of magnetite dust is present as well as some quartz grains. Evidently an altered peridotite.

See also "Amphibolite" [**8322**].

PHILLIPS RIVER ROCKS.

Rd. No.	Collector.	F. No.	Section.	Name.	Locality.
				Acid Rocks.	
1875	T B	..	106	Soda Granite	Three miles W. of Mt. Desmond
1898	T B	..	964	Do.	Jim Dunn Wonder, Ravensthorpe
7911	..	..	..	Do.	Bore Core
8139	H W B T	1	877	Do.	Well, 25 chains S. of No. 2 Tank, Ravensthorpe
8142	H W B T	4	872	Do.	10 chains S.E. from S.E. peg of Recreation Reserve, Ravensthorpe
8147	H W B T	9	876	Do.	10 chains N. of N.E. peg of W.R. 7606, Ravensthorpe
8151	H W B T	13	880	Do.	Western Well on W.R. 7517, Ravensthorpe
8152	H W B T	14	881	Do.	Near S.E. peg of W.R. 8358, Ravensthorpe
8305	H W B T	18	..	Do.	Pipe line, 10 chains W. of N.W. peg of 9977, Ravensthorpe
8306	H W B T	19	..	Do.	S.W. corner of Location 262, Ravensthorpe
8308	H W B T	21	..	Do.	15 chains W. of N.W. peg of Location 2, Cardinup Creek
8309	H W B T	22	..	Do.	Fault on bank of Creek, one mile South of M.H.L. 13
8310	H W B T	23	900	Do.	S. boundary of M.L. 236, Oversight Extended
8314	H W B T	27	965	Do.	M.L. 94, Amazement
8318	H W B T	31	904	Do.	Water Shaft on W.R. 7385
8330	H W B T	43	..	Do.	Road near S. boundary of M.L. 115
8332	H W B T	45	925	Do.	20 chains E. of S.E. corner of Recreation Reserve 7369
8563	HPW	..	954	Do.	Mt. Benson Mine
8566	HPW	..	963	Do.	Mt. Desmond Mine

1912	TB	..	..	Felsite or fine-grained S. Granite	Half-mile N.E. of Ravensthorpe
1913	TB	..	..	Do. do.	Do.
8315	H W B T	28	..	Do. do.	Felsite Dyke, 20 chains S.W. of M.L. 28, Red Hill
8470	HPW	..	921	Quartz Ceratophyre	Mt. Cattlin Mine
8553	K	..	935	Do.	Do.
				Altered Acid Rocks.	
8562	HPW	..	968	Altered Soda Granite	Mt. Benson Mine
5291	Dr. Ch.	..	..	Sericite Schist	Phillips River
8321	HWBT	34	..	Do.	N.W. corner of M.L. 200, Last Chance Proprietary
8558	HPW	..	..	Do.	Mt. Benson Mine
8564	HPW	..	..	Do.	Do.
7827	M	..	837	Sericite and Andalusite Schist..	Elverdton Mine
8143	HWBT	5	873	Andalusite Rock and Schist ..	2 chains N. of N.W. peg of M.H.L. 126, Ravensthorpe
8463	HPW	..	914	Do.	Sunset Mine
8311	H W B T	24	901	Mica-Chlorite Rock or Schist	Near shaft of M.L. 236, Oversight Extended
8364	H W B T	58	..	Do.	One and a half miles W.S.W. of Kundip Tank
8366	H W B T	60	..	Do.	Mosaic Mine
8567	HPW	..	969	Do.	Mt. Desmond Mine
				Intermediate Rocks.	
1876	TB	..	..	(Quartz) Diorite	Three miles W. of Mt. Desmond
1884	TB	..	979	Do.	Near Dr. Jim Mine
1901	TB	..	970	Do.	Lady Annabelle Lease, Ravensthorpe
7824	M	..	834	Do.	Flag Mine, Kundip
8141	HWBT	3	871	Do.	20 chains E. of S.E. peg of Recreation Reserve, Ravensthorpe
8148	HWBT	10	878	Do.	Two chains from W. peg of M.L. 248, Red Hill
8307	HWBT	20	899	Do.	Dyke, 14 chains N. of S.E. peg of 10336, Ravensthorpe
8313	HWBT	26	902	Do.	25 chains N. of junction of Nangutup and Annabelle Creeks
8316	HWBT	29	923	Do.	Near N.W. corner of G.M.L. 132, Darby

PHILLIPS RIVER ROCKS—*continued.*

No.	Collector.	F. No.	Section.	Name.	Locality.
				Intermediate Rocks—continued.	
8320	HWBT	33	949	(Quartz) Diorite	N.E. corner of M.H.L. 39
8363	HWBT	57	911	Do.	Dyke, 50 chains W. of Kundip Tank
8554	K	..	950	Do.	Mt. Cattlin Mine, Mullock Dump
8559	HPW	..	972	Do.	Mt. Benson Mine
8562	HPW	..	968	Do.	Do.
8565	HPW	..	791	Do.	Lucy Mine
1888	TB	..	31	Camptonite	Three miles N.E. of Cocanarup
7825	M	..	835	Do.	P.L.P. Lease
7826	M	..	836	Do.	South Cattlin Mine
8145	HWBT	..	875	Do.	Shaft on M.L. 12, Ravensthorpe
8319	HWBT	32	905	Do.	30 chains N. of N.E. peg of M.H.L. 9
8325	HWBT	38	906	Do.	On Creek, 10 chains W. of N.W. peg of M.L. 249, Ravensthorpe
8465	HPW	..	916	Do.	Mt. Cattlin Mine
8469	HPW	..	920	Do.	Do.
8555	K	..	951	Do.	Mt. Cattlin Mine, Mullock Dump
8560	HPW	..	953	Do.	Mt. Benson Mine
8561	HPW	..	967	Do.	Do.
7822	M	..	832	Kersantite	Elverdton Mine
7823	M	..	833	Do.	Mt. Desmond Mine
7912	HWBT	..	947	Do.	Mt. Cattlin Mine
8462	HPW	..	913	Do.	Elverdton Mine
8466	HPW	..	917	Do.	Mt. Desmond Mine
8467	HPW	..	918	Do.	P.L.P. Mine
8468	HPW	..	919	Do.	Elverdton Mine
8557	K	..	952	Do.	Mt. Cattlin Mine, South Lode

				Altered Intermediate Rocks.	
8324	HWBT	37	..	Altered Comptonite or Kersantite	W. bank of Jerducuttup Creek
8464	HPW	..	915	Do.	James Henry Mine
8531	HPW	..	..	Amphibolite	M.L. 110, Grimsley
1874	TB	..	..	Biotite Schist	Mary Mine
1895	TB	..	..	Do.	Federal Lease
1907	TB	..	..	Do.	Dallinson's Claim, Ravensthorpe
1909	TB	..	..	Do.	Kingston Mine
1906	TB	..	..	Garnetiferous Schist	Dallinson's Claim, Ravensthorpe
8533	HPW	..	..	Do.	Mt. Benson Mine
1877	TB	..	..	Garnetif Hornblende Schist ..	Three miles N.E. of Cocanarup
1883	TB	..	72	Garnet Rock	Mt. Cattlin Mine
1911	TB	..	..	Do.	Overshot Hill
2065	the Warden	..	..	Do.	Fitzgerald River
5289	Dr. Ch.	..	..	Garnet Rock Schistose ..	Phillips River
8155	..	17	883	Hornblende Eclogite	35 chains W.N.W. of N.E. peg of M.L. 227, Last Chance
				Quartz Diorites with Chalcedony.	
8149	HWBT	11	879	Quartz Diorite with Chalcedony	Annabelle Creek, W. of M.L. 14
8317	HWBT	30	903	Do.	W.R. 7385
8327	HWBT	40	907	Do.	Near Elverdton Dam
8359	HWBT	53	910	Do.	25 chains N.W. of N.W. corner of G.M.L. 101, Ard Patrick
				Basic Rocks—Diabases, etc.	
6052	M	..	766	Diabase	Last Chance G.M., Mount Desmond
8140	HWBT	26	973	Altered Diabase	10 chains N. of N.W. peg of M.H.L. 16, Ravensthorpe
8144	HWBT		874	Diabase	30 chains N.W. of S.E. peg of W.R. 7517, Ravensthorpe
8328	HWBT	41	908	Diabase altered, containing serpentine with bastite	Five chains S. of S.W. peg of M.H.L. 67

PHILLIPS RIVER ROCKS—*continued.*

Rd. No.	Collector.	F. No.	Section.	Name.	Locality.
				Basic Rocks.—Diabases. etc.—continued.	
8568	HPW	..	966	Diabase	Mt. Desmond Mine
8150	HWBT	12	..	Interbanded Acid and Basic Rocks	Annabelle Creek, 3 chains W. of M.L. 14
				Amphibolites, etc.	
8322	HWBT	35	948	Amphibolite	One mile S. of junction of Cardinup and Jerdacuttup Creeks
8154	HWBT	16	882	Serpentine	50 chains W.N.W. of N.W. peg of Quarry Reserve
8326	HWBT	39	924	Do.	Two miles S. of M.L. 266, Grand Seam, 10027
8534	HPW	..	..	Do.	McLeod's "Spec"
7828	M	..	838	Much altered Rock allied to above	Mt. Chester Tunnel
8361	HWBT	55	..	Much altered Rock	Near S.W. peg of T.A. 2
				Pegmatites, etc.	
1855	TB	..	29	Pegmatite	Two miles S.W. of Cocanarup
1856	TB	..	..	Tourmaline Granite	Do.
1860	TB	..	..	Mica Pegmatite..	Do.
1863	TB	..	..	Spodumene Pegmatite ..	Half-mile South of Ravensthorpe
1863	M	..	..	Do.	From excavation at Head's Smelter
1878	TB	..	..	Pegmatite	Three quarters of a mile S.S.W. of Ravensthorpe, P.R. M.D.
5281	Dr. Ch.	..	..	Pegmatite	Phillips River
7956	..	..	..	Spodumene in Pegmatite ..	Cattlin Creek, W.R. 17
8529	HWBT	..	..	Pegmatite	W. of M.L. 74, Ravensthorpe
1885	TB	..	..	Jasper Rock	Near Dr. Jim Mine
5290	Dr. Ch.	..	..	Do.	"Phillips River"

				Sedimentary, etc.	
8 46	HWBT	8	..	Ferruginous Sandstone and Conglomerate	35 chains N.E. of S.W. peg of W.R. 7607, Ravensthorpe
8323	HWBT	36	..	Ferruginous Sandstone ..	N. side of Cardinup Creek, 50 chains above junction
8329	HWBT	42	..	Altered Sedimentary Rock ..	M.H.L. 290, King of Iron Knobs
8331	HWBT	44	909	Ferruginous Sandstone ..	E. boundary of Experimental Reserve 9109
8352	HWBT	46	..	Altered Shale or Mudstone ..	10 chains W.N.W. of N.W. corner of C.L. 130, Alice
8353	HWBT	47	..	Ferruginous Sandstone ..	15 chains E.S.E. of S.E. corner of M.L. 235, Victory
8354	HWBT	48	..	Do.	20 chains E.S.E. of S.E. corner of M.L. 242, Lone Star
8355	HWBT	49	..	Partly Metamorphised Sandstone	Near N. corner of G.L. 132
8356	HWBT	50	..	Do. do. ..	At Dam, on T.A. 2, near Flag Mine
8357	HWBT	51	..	Conglomerate	Near above (No. 8356)
8358	HWBT	..	52	Altered Shale	Three chains S. of S. corner of M.L. 251, (216) Harbour View South
8360	HWBT	54	..	Argillaceous Sandstone ..	25 chains W. of N.W. peg of G.L. 107. Ard Patrick
8362	HWBT	56	..	Sandstone	30 chains S. of Kundip Tank
1914	TB	..	..	Quartzite (? a Dyke)	Half-mile N.E. of Ravensthorpe
7811	..	..	..	Saliferous Rock	West River
8312	HWBT	25	..	Travertine with Shells	Salt Pool at junction of Anabel and Nangutup Creeks
6049	M	..	..	Auriferous Ironstone	Mt. Desmond

MINERAL CENSUS.

N.B.—The common rock-forming minerals are omitted from this list, except when cabinet specimens of them are obtainable. Those minerals of which good specimens occur freely are printed in capitals.

Record No.	Dana's No.	Mineral.	Locality.
7098, etc.	13	GOLD	District generally.
4436	31	Tetradymite	G.M.L. 43, Floater, Ravensthorpe.
8404	34	Molybdenite	Near Ravensthorpe.
6229 etc.	54	Chalcosite	G.M.L. 109, Mount Desmond and elsewhere.
6228	67	Covellite	G.M.L. 109, Mount Desmond and elsewhere
..	74	Pyrrhotite	District generally.
7909, etc.	78	Bornite	District generally.
8383, etc.	83	CHALCOPYRITE	District generally.
..	85	PYRITES	District generally.
8091, etc.	96	Marcasite	District generally.
6227, etc.	149	TENNANTITE..	Mosaic Mine, Kundip.
7812	166	Halite	West River.
5296, etc.	193	Atacamite	Detected in considerable quantities in several assay samples.
6246, etc.	224	Cuprite	District generally.
6223	230	Tenorite..	M.L. 7, Mary
1890, etc.	237	Magnetite	M.L. 143, Kingston Lease, etc.
4444, etc.	269	PSILOMELANE	East of M.L. 112, Mount Desmond.
5436	272	MAGNESITE	Kundip.
8351	288	MALACHITE	District generally.
6728	289	Azurite	M.L 206, Hecla, and elsewhere.
8490, etc.	316	ALBITE..	Ravens horpe (Head's Smelter)
7956, etc.	327	SPODUMENE	Ravensthorpe (Head's Smelter).
8125	338	Asbestos (Actinolite)	Phillips River District.
7964, etc.	370A	Grossularite	Near R 2, Cardinup Creek, etc.
8143	398	Andalusite	Near N.W. peg of M.H.L. 12, and Sunset Mine, Ravensthorpe.
8487–9, etc.	426	TOURMALINE, black, green, and pink	Ravensthorpe (Head's Smelter).
1861	458	Muscovite	Two miles S.W. of Cocanarup.
4443	458	Fuchsite	Phillips River.

1858, etc.	460	LEPIDOLITE	Cocanarup and Head's Smelter, Ravensthorpe.
8326, etc.	481	Serpentine	Two miles S. of G.M.L. 266, Grand Slam, etc.
8153	492	Kaolin	Quarry, 1 mile S. of M.H.L. 16, and elsewhere.
7012	493	Halloysite	Ravensthorpe.
8350	561	Olivenite	G.M.L. 99, Alice Mary, Kundip.
8350	601	Erythrite	G.M.L. 99, Alice Mary, Kundip.
8471	814	Scheelite	10 miles S.W. of Kundip and Dallinson's Reward, Ravensthorpe.

PART III.—Description of the Mines.

Historical.—The history of this field may be said to commence in 1892, when the Brothers Stennett discovered gold in small quantities in conjunction with copper and iron pyrites, but owing to the scarcity of fresh water in this locality and to the fact that sensational discoveries were made about this time at Coolgardie, the further prospecting of this district was for the time being abandoned.

The present writer crossed this field upon his way to act as the first Warden of the Dundas about this period, and was so favourably impressed with its mineral character that he strongly recommended further prospecting.

In the early part of 1899, the Dunn Brothers discovered auriferous quartz upon the western edge of the mining belt, not far from their homestead at Cocanarup, where they applied for a lease which they called the Jim Dunn's Wonder, but although the official statistics do not show any return from this lease, it undoubtedly drew attention to this district, for shortly afterwards a large number of others were pegged out and applied for to the northward upon the same line of country.

The original discoveries, as a rule, consist of fragments of auriferous quartz, scattered over a clayey surface, which was mostly covered with dense scrub, whilst the reefs had to be prospected for by trenching.

Prospecting in these early days was conducted under great difficulties on account of the scarcity of fresh water, whilst owing to the fact that the whole area is pretty thickly covered with poison plant, neither horses nor stock could be depastured.

The discovery of this belt of gold reefs was quickly followed by that of the copper lodes in the vicinity of Ravensthorpe, also at the foot of the range to the north-eastward, which are now known as the Mt. Benson group.

In the early part of 1900 Mr. Torrington Blatchford, Assistant Government Geologist, inspected this field, his report upon which, accompanied by a geological sketch map, was published in June of that year as Bulletin No. 5 of this Department.

On account of further discoveries being made during the same year, of the Mt. Desmond and Kundip Centres, a further inspection became necessary; therefore, the services of the present writer were requisitioned, his report appearing in the Annual Progress Report of this Department for 1901.

Early in the year 1903, Mr. A. Montgomery, State Mining Engineer, visited this field with the object of advising the Government regarding the erection of State Smelting Works, and his full report

in pamphlet form was published by the Mines Department in the same year. These smelting works were then erected and run with varying success, first at a position upon the Cordingup Creek, and later at the present site, which is about one mile to the eastward of the town.

The State Mining Engineer's report was supplemented by one dated June, 1905, published in the Annual Report of the Mines Department for 1904, and also by notes on the progress of the State Smelting Works in the Annual Reports for the years 1905 and 1906.

In the year 1906, these works were sold by the Government to the Phillips River Gold and Copper Company, Limited, who have now greatly increased their capacity by the addition of reverberating furnaces and a converter.

Towards the end of 1907, the State Mining Engineer was again despatched to the field with the object of advising the Minister as to whether the prospects of the district warranted the Government in the construction of a railway line from the Coast; his full report appeared in the Annual Report of the Mines Department for 1907. Mr. Cullingworth, the Inspector of Mines, also wrote several reports which appeared in the Press of the same year. Since many of the mines examined and reported upon by these officers are either closed down or an inspection of the upper levels is now impossible, it will assist very greatly in the study of these ore deposits if the reports above referred to are read in conjunction with the present.

The railway line is now an accomplished fact, whilst several good reservoirs have been constructed, which supply water both for domestic and mining purposes.

The Mines.—This field is at the present time passing through a period of extreme depression, which is very generally ascribed to what is called the "slump in the copper market," if, however, the market price obtained for this metal a few years back is recalled, it will at once be apparent that this cannot be the sole reason, since the present price is as high as it was at the inception of the field, the low value being more apparent than real, since it is only comparatively so with the abnormally high figure reached a year or so back.

The low market is, therefore, clearly not responsible for the existing state of things, which may with much greater reason be ascribed to the liberal Government assistance which has enabled men without capital to mine the richest portions of a number of lodes from the surface down to the water level and to dispose of the ore for cash at the State Smelters upon the most favourable terms, the result being that so long as the rich and cheaply worked bunches lasted, a mild boom set in, whilst this was further prolonged by the rise in the copper market above referred to, which rendered much lower grade ore payable.

Upon the top of this boom, certain capitalists secured options over a number of properties and upon these vigorous development

was commenced, with the result that a considerable impetus was given to business in the town, where a large number of new buildings were erected. Owing, however, to the sudden fall in the market, it was found impossible at the time to launch these mines successfully upon the London market, and, in consequence, some have been abandoned, whilst upon the remainder only a limited number of men are employed.

At the present time, a large number of the smaller mines are at a standstill, owing to the fact that the greater portion of the marketable ore above the water level has been raised, whilst funds are not available for the purchase of the necessary machinery to develop them further, the consequence being that the owners have been living in hope that the completion of the railway line would either cause a very considerable reduction in the smelting charges or a revival of interest to take place, which latter would enable them to sell out at a profit, but since these properties have, in the majority of cases, been so favourably reported on officially, a much higher price is expected than there is any likelihood of being obtained.

The condition of the small holders upon this field is, therefore, in a very bad way, which neither the railway line nor cheaper smelting can but temporarily relieve, for if during the boom time the lease owners were unable to purchase plant to work their mines below the water level, they have little prospect of doing so upon the realisation from lower grade ores.

There can be no question but that the future of this field is entirely dependent upon the introduction of outside capital, it is, therefore, to be sincerely hoped that those properties still held by the Phillips River Gold and Copper Company will develop up to expectations, for if such is the case, confidence will be established and many others will be taken up and worked. Should, however, anything unforeseen occur to cause this company to cease operations, this field may be considered as dead, for it would be impossible to induce persons to provide further capital for a considerable time upon the top of an acknowledged failure.

In the description of the mines which follows, the three main centres of Ravensthorpe, Mt. Desmond and Kundip, have been taken separately, whilst the first mentioned of these has been subdivided into three groups, called respectively, the Western, the Central, and the Eastern.

The first of these latter embrace the earliest discovered lodes, which are contained in what may be called the auriferous belt, but since these are now practically abandoned, any reliable information regarding them can only be obtained by reference to the official publications previously mentioned, and this remark also applies to certain of the copper mines in the Central and Eastern Groups of the Ravensthorpe Centre.

Generally speaking, the lodes are of one character, viz., basic intrusions, usually highly ferruginous and siliceous at the surface,

where they are, as a rule, practically destitute of copper, but fairly rich in gold, whilst in the balance of the oxidised zone they may, in addition to gold, carry a considerable percentage of copper, which occurs in the form of ferruginous oxi-carbonates. In the sulphide zone and below the water level, the gold values perceptibly decrease, or practically cease, whilst the copper and iron ores pass directly from carbonates and oxides into primary sulphides, with scarcely any indication of secondary sulphide enrichment.

The richer portions of both the copper and gold lodes above the ground water level, are purely secondary enrichment, lacking both size and definition, and, therefore, cannot correctly be described as shoots, whilst below it, the sulphides are mostly disseminated through a body of lode stuff of considerable size, upon which in only one or two instances, has sufficient development been done to prove their character.

With the exception of the Mt. Cattlin and the Elverdton mines, little has been done below the water level, therefore, it is at the present time impossible to state with any degree of certainty how these ore bodies will behave at a greater depth, but so far as the evidence goes they will, in the majority of cases, prove to be of too limited extent to be payable when the hard country is struck; others again promise to be a fair size, but of very low grade, whilst the remainder which are of considerable size, promise to yield a large quantity of low grade ore suitable for concentration.

Some of the mines are worked exclusively for gold, but these, like those in the Western Group, will, in all probability, make into low grade copper lodes at a depth when, even if the gold values do not fall, the veins are too small and the values too low to be worked profitably in the hard country below the water level.

In the copper mines proper, the ore has, up to the present, been hand picked, the higher grade sent to the smelting works and the more siliceous lower grade, if carrying high gold values, to the battery, by which latter process about 40 per cent. of the contents is recovered, whilst the sands, after passing over Wifley Tables, contain too high a percentage of copper to be amenable to cyanide treatment.

The returns furnished by the various mine owners do not represent the tonnage raised, since a large quantity of the low grade ore is thrown upon one side, whilst the balance is divided into two classes, one called firsts, or copper ore, and the other seconds, or crushing stone. The first of these is sold upon assay and the returns furnished being total metallic contents, whilst the second is crushed at a battery, when the extraction return is given, which, as before stated, is usually only about half of the total gold contents. The concentrates from the battery treatment are also smelted for copper, but the returns under this head do not show the total amount of ore from which they were obtained, but in its place only the tonnage of a concentrated portion, whilst the value given in pounds sterling

does not represent the sum paid for the ore, but the full market price at the time of the metallic copper contents of the ore.

Under the gold returns, upon the other hand, the number of tons crushed are given, but against this only the quantity of gold recovered by amalgamation, which is usually under half the contents. It will be apparent from this that the value of one portion of the ore is over stated, since no deductions are made for loss, but in the second it is not credited with the concentrates which actually are a portion of it, whilst the value of the ore is absolutely fictitious, because it represents the total metallic contents reduced to its highest state of purity upon the London market.

In the following table, the totals show all the ore treated, either by smelting or battery, the gold being the total of the assay returns from account sales notes added to the quantity recovered by amalgamation, and is stated in fraction of ounces per ton, whilst the copper contents is based upon a percentage of the total tonnage treated.

In the grand total for the last eight years of this field's existence, it is shown that the ore which, upon the average, contained 4 per cent. of copper and ½ ounce of gold, may be roughly valued at £4 10s. per ton. The very apparent falling off in the value of the copper ore production for 1908 is more apparent than real, being entirely due to the fact that the smelting works were closed down, therefore little ore was sold, whilst a larger quantity was crushed as seconds.

The usual practice of dealing with such questions as water supply, timber, fuel, fluxes, means of transport, smelting works, machinery and mining methods, together with the class, quantity, and suitability of the ore for smelting, concentration, or other metallurgical treatment, will not be touched upon here, since they have already been so exhaustively reported upon by the State Mining Engineer, to whose province they properly belong.

Table showing the Yield of Gold and Copper from the Phillips River Goldfield.

Year.	Ore treated.	Gold therefrom.	Rate per ton.	Copper therefrom.	Copper value.
	tons.	ozs.	ozs.	tons.	%
1900	34.00	36.72	1.08	10.18	30.00
1901	1,281.14	665.83	0.52	258.54	20.00
902	9,698.50	7,441.30	0.76	23.36	0.24
1903	9,741.08	7,050.73	0.72	214.59	2.20
1904	9.738.49	4,016.63	0.41	485.02	5.00
1905	5,098.54	2,563.26	0.50	307.66	6.00
1906	5,086.68	2,779.89	0.54	287.24	5.63
1907	14,104.62	4.313.87	0.31	658.73	4.67
To June, 1908 ..	3,611.38	1,718.18	0.50	62.95	1.74
Total ..	58.394.43	30,586.41	0.52	2,308·27	4.00

THE RAVENSTHORPE CENTRE.

This centre includes three quite distinct groups of mines which lie round the township from the north-eastward to the south-westward.

The first of these, which may be called the Western group, stretches in one almost unbroken line eight miles in length, which strikes in a north-east and south-west direction, the nearest point of which belt is about two miles north-west of the town.

These mines, without exception, were originally worked exclusively for gold, some of them carrying fairly high values near the surface; at greater depths, however, when the sulphide zone was reached, they invariably become poor.

There are only two in this group worthy of the name of mine, viz.: the Maori Queen and the Floater, the latter being the only one still held, although at present under exemption.

The second or Central group consists entirely of copper mines, which lie scattered in an irregular manner in the zone of dislocation which is situated immediately to the northward of the town, and extends as far as the Mt. Cattlin mine.

This group contains the original copper discoveries of this field and also the deepest mine.

The Eastern group are also copper mines, which lie in the contact zone close to the base of the range, but strike off from it in a westerly direction.

As before stated, the gold mines are practically all closed down, whilst with the exception of one or two of the copper mines they are pretty well in the same condition, the reason in the first-mentioned case being that the values gave out in the hard country, and in the latter practically all the accessible ore has been raised, whilst that in the hard country below the water level cannot be worked without machinery, even if the lode prove to be large and rich, of which in most cases there is very considerable doubt.

The Western Group.—In the greenstone area, which lies to the north-westward of the town, a belt of mines about eight miles in length have been worked for gold.

This group of mines, although the first discovered upon the field, have not as a rule been extensively worked, and are now mostly abandoned owing to the small size of the lodes, the limited extent of the payable stone, and the hardness of the enclosing rock below the water level.

Outcrops are of rare occurrence, the surface being usually covered by a layer of red clay about six feet in thickness, clothed by fairly dense scrub, the only indication of reefs being strewn fragments of quartz.

The lodes in this area are mostly siliceous and much iron-stained enclosed in a solid amphibolite country often intersected by small pegmatite dykes.

At a comparatively shallow depth, and before the ground water level is reached, sulphides of iron and copper make their appearance, and the lode matter passes into a schistose greenstone, whilst gold values materially decrease.

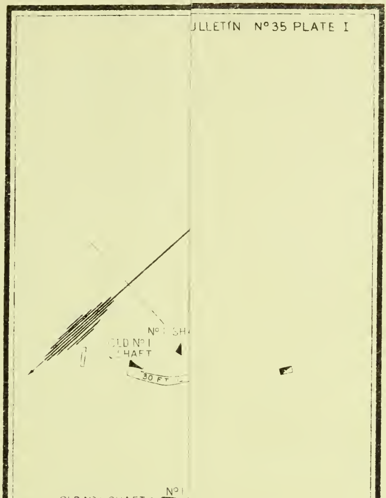
For particulars with regard to them reference should be made to the previous official reports mentioned in the introduction.

Table showing the Yield of the Mines of the Western Group—Ravensthorpe Centre.

Year.	Name and Number of Lease.	Ore treated.	Gold therefrom.	Copper therefrom.
		tons.	ozs.	tons.
1902	Alpha, G.L. 20	10.00	2.63	
1902	All for the Best, G.L. 3 ..	35.00	18.92	
1903–7	Bobby Dazzler, G.L. 115	18.00	38.59	
1902	Bridgetown, G.L. 15 ..	15.00	8.76	
1902	Christiana, G.L. 36 ..	50.00	13.14	
1902	Commonwealth, G.L. 10 ..	60.00	28.91	
1902	Coronation, M.L. 48 ..	31.00	18.14	
1902	Cousins Glory, M.L. 13 ..	80.00	32.46	
1902	Cumberland, G.L. 38 ..	20.00	3.50	
1902–4	Ellendale, M.L. 26 ..	70.00	36.80	
1906	Ellen Tommy, G.L. 93 ..	34.00	14.26	
1904	Eureka, G.L. 64	29.00	33.38	
1901–8	Floater, M.L. 21	12,881.19	10,933.81	.49
1902	Floater Proprietary, G.L.45	30.00	14.89	
1902–3	Golden Link (Day Light), G.L. 63	45.00	30.25	
1902–7	Grafter, M.L. 202	295.65	370.89	1.99
1902	Harwick, G.L. 41	15.00	8.76	
1901–4	James Henry, G.L. 26 ..	406.00	514.67	
1902–5	Jubilee (Diamond Jubilee), G.L. 75	124.00	58.94	
1902–3	Lady Jessie, M.L. 74 ..	77.00	58.43	
1902–4	Lucy, G.L. 21	269.00	174.78	
1902–3	Maori Chief, M.L. 4 ..	22.00	15.54	
1901–7	Maori Queen, G.L. 1 ..	5,086.17	4,100.53	.18
1902–7	Mt. Elya (Princess Royal), G.L. 88	160.50	106.07	
1903–5	Plantagenet, G.L. 76 ..	556.00	185.92	
1902	Sirdar (Two Bobs), G.L. 60	66.00	49.45	
1902	Waratah, G.L. 34 ..	6.00	2.06	
	Total	20,491.51	16,874.48	2.66

Maori Queen, G.M.L. 1. (Plate I.)—This the first gold-mining lease issued in this district, is situated about $2\frac{1}{2}$ miles to the north-eastward of the township. It was worked for some years by the Phillips River Gold Mining Co., N.L., who equipped it with a battery and winding engine, and raised and treated over 5,000 tons of stone.

The lode, which has a north-easterly course, has been traced at the surface for a length of $8\frac{1}{2}$ chains by a series of shafts and



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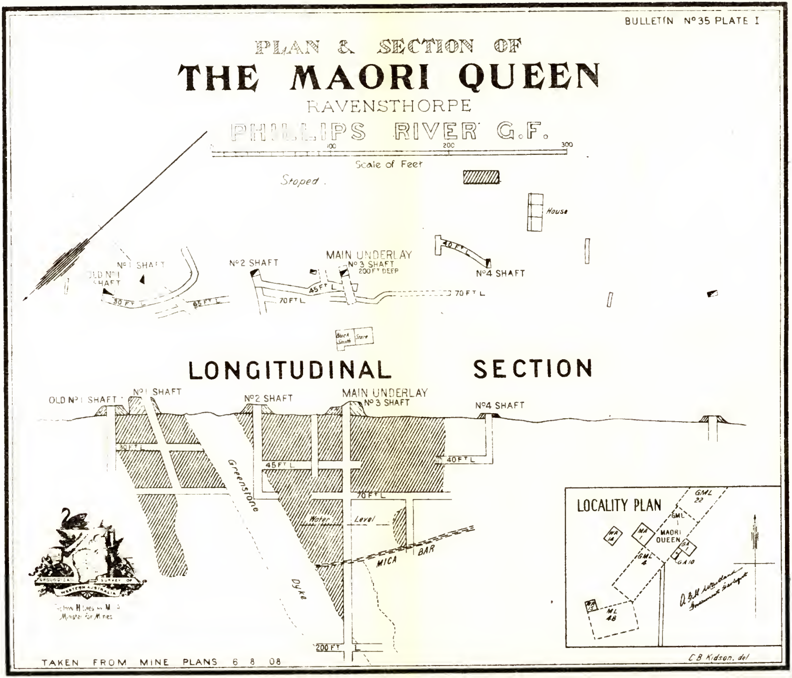


H J Pether, Government Lithographer, Perth, W.A.

trenches, but of this only 280 feet proved to carry high enough values to be payable, whilst in this section the lode was intersected by a dyke of barren rock 40 feet in width.

This reef dips to the north-westward at an angle of 75 degrees to the 70 feet level, below which it pitched and went down nearly vertically.

In the oxidised zone, which extends only to a depth of 30 feet, the lode was about 4 feet in width, but below this it became highly mineralised, and carried a little chalcopyrite, whilst in size it varied from 1 to 4 feet, which became further reduced to from 6 to 18 inches at the bottom of the main shaft. From the surface down to the water level (about 80 feet) that portion of the lode lying to the southward of the dyke has been stoped for a length of 160 feet, but of this only the 40 feet nearest to the intrusion was of high grade, and this portion only was stoped down to the 200 feet level when even this became poor.

In the northern workings the lode has been stoped to the 70 feet level for a length of 70 feet, but below this only the northern section of 20 feet has been stoped down to the 100 feet level.

The footwall of this lode is granitic, and the hanging wall is amphibolite, whilst a large acidic dyke and several small pegmatite veins intersect it.

It has recently been worked in the upper levels by some working miners, but has since been entirely abandoned.

Table showing the Yield of the Maori Queen Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold. therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1901	Maori Queen, G.L. 1 ..	170.00	139.6.	.82
1902	Do.	2,720.00	1,811.14	.66
1903	Do.	1,490.00	1,087.15	.73
1904	Do.	600.00	770.76	1.21
1905	Do.	90.00	240.25	2.66
1907	New Maori Queen, G.L. 119	*16.17	51.59	3.20
		5,086.17	**4,100.53**	.85

*Yielded .18 ton copper.

Plantagenet, M.L. 50.—This old abandoned mine is situated just within the greenstone area, about half-a-mile to the westward of the Maori Queen.

The reef, which strikes in a north-easterly direction, and underlays slightly to the north-west, has been sunk upon at two points to a depth of about 70 feet, the stone being fairly rich near the surface, but became very poor in the sulphide zone which came in below 30 feet. The stone also became more schistose, and very hard, carrying a little chalcopyrite.

Table showing the Yield of the Plantagenet Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1903	Plantagenet, G.L. 50 ..	160.00	109.75	.68
1904	Do.	282.00	53.64	·17
1905	Do.	27.00	9.07	.33
1905	Planet, G.L. 76	87.00	13.46	.15
	Total	**556.00**	**185.92**	**.33**

Grafter, G.M.L. 202.—This lies a short distance to the northwestward of the Plantagenet, and attracted considerable attention in the early days on account of the richness of the stone, the first parcels of which averaged about 3 ozs. of gold to the ton.

There are three lines of lode on this lease, the western one, which strikes north and south with a dip to the westward, has been sunk upon to a depth of about 70 feet; it varies from 12 to 48 inches in width. and is cut through by a small pegmatite vein.

The next vein, which strikes a little to the east of north and dips at an angle of 75 degrees to the westward, has also been sunk upon to a depth of 70 feet; it is a dense quartz, making into foliated greenstone carried between good walls, but although of high grade, it averaged only about one foot in thickness.

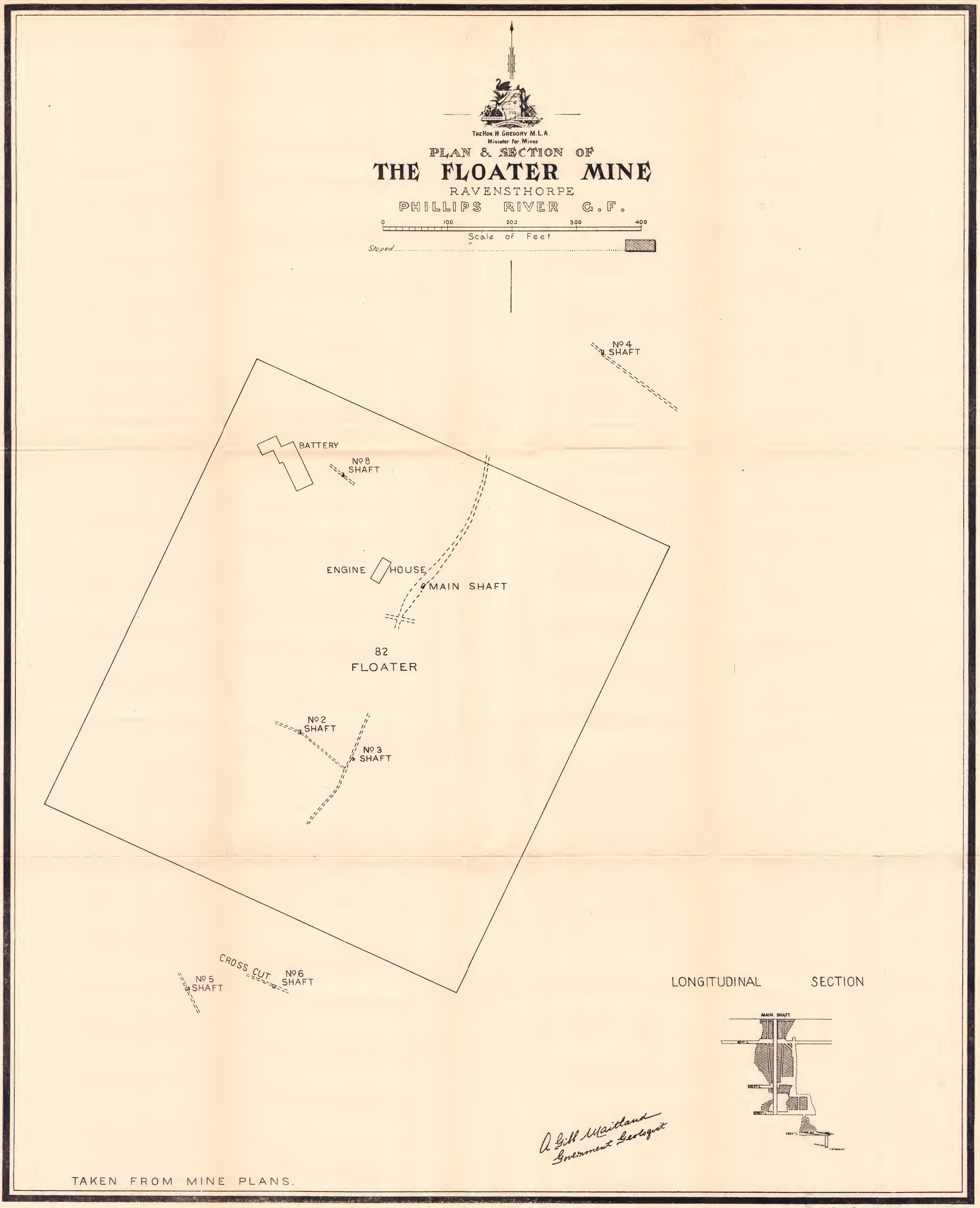
The other lode, which had an ironstone outcrop, is called the copper lode, and this has been sunk to a depth of 30 feet, and also crosscut from the 70 feet shaft last mentioned, which is about 30 feet distant. It is about 5 feet in width, but was of low grade; 68 tons of hand picked ore smelted in 1906-7 returned only 3 per cent. of metallic copper.

Table showing the Yield of the Grafter Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1902	Grafter, G.L. 17	66.00	99.34	1.50
1903	Do. do.	125.00	192.15	1.54
1904	Do. do.	36.50	44.94	1.23
1905	Do. do.	..	*20.03	..
1906	Grafter, G.L. 202	8.79	1.76	.20
1907	Do. do.	†59.56	12.67	.21
	Total	**295.85**	**370.89**	**1.29**

* From cyanide. † Yielded 1.99 tons of copper.

Floater, G.M.L. 82 (Plate II.).—This mine was called the Floater by the original prospectors from the fact that no reef out-



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cropped, but some fairly rich specimens of auriferous quartz were discovered lying about upon the surface (called "floaters"), the vein from which they were derived being only located after some 6 feet of clay was sunk through.

It is situated about 2¼ miles north of Ravensthorpe, and has been held for some years past by the Gilbert Gold Mines, Ltd., who have equipped it with a battery and winding engine.

The reef proved to have an easterly course and to go down nearly vertically, but although it was traced at the surface for a considerable distance by trenches and shallow shafts, it was only rich for a short distance. The zone of enrichment goes down nearly vertically, but with a slight pitch to the eastward; it averages 70 feet in length and 8½ feet in thickness, and has been followed down for a depth of 316 feet.

A main vertical shaft has been sunk in the ore body to a depth of 236 feet, from which the lode has been worked by three levels, the No. 1, or 60 feet, has been driven for a distance of 120 feet north and 240 feet south in payable ore for a length of only 68 feet.

Above this level the stone was mostly quartz, much ironstained, and often showing a considerable quantity of gold, but below this its character changed to the typical schistose greenstone containing sulphides of iron and copper and in places a little telluride of bismuth. It also contains quartz in veins and bunches often firmly attached to the walls of the lode, which are irregular and show no signs of movement. The lode was intersected at several points by thin flat veins of pegmatite, called mica bars owing to the fact that they consist largely of that mineral.

The ore body attained its maximum longitudinal extent at a depth of 110 feet, where it was 104 feet in length, below which it rapidly diminished, being 64 feet at the 236 feet level and only 44 at the winze bottom, which is 286 feet below the surface.

The gold values also steadily decreased with depth, starting at 1.14ozs. per ton in the upper levels and falling to .12oz. at the bottom.

Table showing the Yield of the Floater Mine.

Year.	Name and Number of Lease.	Ore Crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1901	Floater, G.L. 43	*49.19	104.79	2.13
1902	Do. do.	3,558.00	4,060.28	1.14
1903	Do. do.	5,740.00	4,9 9.32	0.85
1904	Do. do.	3,135.00	1,628.99	0.52
1905	Do. do.	151.00	62.89	0.41
1906	Do. do, ...	96.00	88.87	0.92
1907	Floater, G.L. 82	140.00	59.60	0.42
1908	Do. do.	12.00	19.07	1.59
	Total	**12,881.19**	**10,933.81**	**0.58**

* Yielded 0.49 ton of copper.

James Henry, G.M..L. 26.—This is one of the typical auriferous lodes of the district, the character of which is that they do not outcrop at the surface, where the only indication of their presence was given by strewn quartz fragments containing gold.

Beneath a few feet of clay the cap of a ferruginous quartz reef was discovered, which had a strike of about 35 degrees east of north and a dip of from 75 to 80 degrees to the westward.

A main shaft has been sunk to a depth of 126 feet in a massive hornblende rock containing large crystals of that mineral, brackish water being struck at a depth of 90 feet, which made at the rate of 4,000 gallons in the 24 hours.

At a depth of 80 feet a level was driven for a length of 80 feet, in which the payable ore was 65 feet in length and averaged about 2 feet in width. This body, which has apparently a northerly pitch, is said to have been stoped up to the surface, but cannot have averaged more than one foot in thickness if the tonnage reported as raised from this mine is correct.

The upper portion of this lode was oxidised, but from 40 feet or 50 feet down it contained large quantities of iron and a little copper pyrites.

A small western vein has also been worked by an opencut, and several small shafts to a depth of 40 feet. This underlies to the southward, or towards the other lode, whilst it strikes almost east and west, and therefore should junction with it a few chains north of the workings.

Table showing the Yield of the James Henry Mine.

Year.	Name and Number of Lease.	Ore Crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1901	James Henry, G.L. 26 ..	22.00	68.41	3.11
1902	Do. do.	210.00	214.35	1.02
1903	Do. do.	99.00	141.77	1.43
1904	Do. do.	75.00	90.14	1.20
	Total	406.00	514.57	1.26

Lucy, G.M.L. 21.—This old abandoned lease, which was previously known as the Lady Annabel, was worked by two shafts, one 120 feet and the other 100 feet in depth.

At this level the lode, which averaged about 3 feet 6ins. in width, has been driven on for a distance of 100 feet and portions of it stoped up to the surface.

The lode did not outcrop, but was covered by several feet of earthy detritus; it proved to have a strike of north-east with a dip of about 80 degrees to the westward, and to consist of a highly ferruginous quartz down to the water level (30 feet), below which

it changed into a heavy pyritic body carrying a little copper, the enclosing rock being a dense amphibolite.

From this mine 269 tons of stone were crushed, which yielded 174.78 ounces of fine gold, or at the rate of .65 ounce per ton, there apparently being no record of the sands treated.

Table showing the Yield of the Lucy Mine.

Year.	Name and Number of Lease.	Ore Crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1902	Lucy, G.L. 21	68.00	59.57	0.87
1903	Do. do.	151.00	89.61	0.59
1904	Do. do.	50.00	25.60	0.51
	Total	**269.00**	**174.78**	**0.65**

The Central Group.—This group of mines are situated in the intrusive greenstone areas, close to and upon the northern and northwestern side of the township, the lodes in which often occur at the contact with the granite.

The lodes are of the usual basic dyke order, containing a considerable quantity of quartz in the upper levels, which is apparently of metasomatic origin, as probably is the gold also to a very considerable degree.

One of the striking features of these lodes is the occurrence of primary sulphides quite near the surface and considerably above the ground water level, whilst like the other lodes of the district, metallic copper, oxides, and secondary sulphides are rarely present.

In the oxidised zone the carbonates may occur in a fairly concentrated form, but this is rarely the case with the sulphides, which are more disseminated throughout the entire lode mass, whilst when they do occur as veins or bunches, they often consist largely of iron sulphides, the result being that the general grade in copper is low, but since the cupriferous formations are usually of considerable size this trouble can be overcome by concentration.

Generally speaking these mines have passed beyond the means of working miners, since capital is required for their further profitable development.

The large output from the Cattlin mine in 1906/7, when the price of copper was phenomenal, has placed the production of this portion of the district ahead of the others, but at the same time, on account of the low grade of the ore raised, the average percentage was decreased, thus the 10,700 tons of ore only returned an average of 7 per cent.

Table showing the Yield of the Mines of the Central Group—Ravensthorpe Centre.

Year.	Name and Number of Lease.	Ore treated.	Gold therefrom.	Copper therefrom.
		tons.	ozs.	tons.
1907	Andante, M.L. 207 ..	17.00	6.60	..
1904–7	Copper Horseshoe, M.L. 244	14.98	..	2.03
1901–3	Grimsby, M.L. 110	5.85	..	0.59
1901–8	Marion Martin, M.L. 16 ..	1,460.79	56.48	167.36
1902–7	Mt. Cattlin, M.L. 15	8,102.99	1,890.83	433.96
1901–7	Mt. Cattlin West (Zealandia, Puzzle and Puzzler), M.L. 219	127.02	0.59	21.87
1903–7	Sunset, M.L. 115	507.44	..	52.34
1901–7	Surprise, M.L.114	466.46	..	56.81
1904	Turn of the Tide, M.L. 166 ..	4.21	..	0.25
	Total	10,706.74	1,954.50	735.21

Mt. Cattlin Copper Mine, M.L. 15 (Plate III.).—This, the largest and most highly developed mine upon this field, is situated about one mile north of the township of Ravensthorpe, and for many years, in fact up to the time it was acquired by the Phillips River Gold and Copper Co., little ore had been raised owing to the fact that it was not generally of a sufficiently high grade to pay for treatment at the then low value of copper. As, however, fairly extensive development had taken place, the company were in a position to take advantage of the rise in the market by putting out 7,621 tons of 5½ per cent. ore.

This mine has now been opened up by four levels, the 100 feet, or No. 1, being 740 feet in length; the 200, or No. 2 level, 640 feet in length; the No. 3, or 300 feet level, 460 feet; whilst at the No. 4, or 400 feet level, the lode has so far only been driven on for a length of 200 feet.

In these levels a large formation, which varies from 4 to 30 feet in width, has been driven on and crosscut, the highest grade portions being apparently confined to four zones, which pitch to the south-west.

This lode, which has a course of north 63 degrees east and practically a vertical dip, is a cupriferous basic dyke, some few feet of which in the bottom levels is often of high grade and exhibits a foliated structure consisting of bands of greenstone, quartz, and chalcopyrite, whilst the poorer portions are composed of greenstone and quartz with pyritic minerals in splashes or disseminated throughout the entire mass, these latter consisting of pyrrhotite, marcasite, and chalcopyrite.

In this mine the oxidised zone only extends downwards for 54 feet, below which the primary sulphides were met with without any appreciable zone of secondary enrichment, what little has taken

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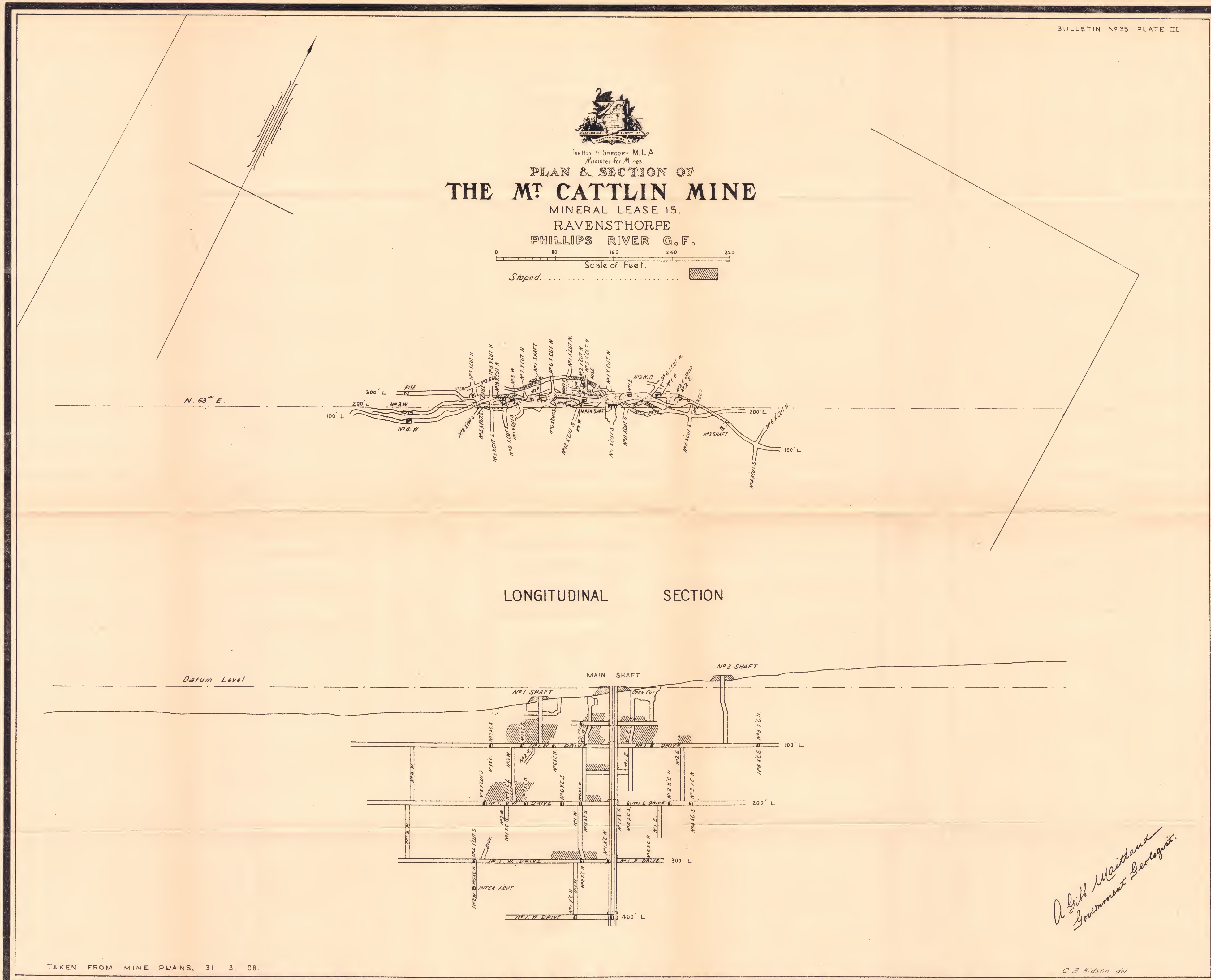

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place being confined to the dislocation or fracture planes in the lode, which have allowed free passage to the downward flow of circulating waters.

Taking the lode all through it is a large low-grade pyritic body, in which the zones of higher value run in shoots which pitch to the westward, and which, although not of so high a value in the bottom as in the upper levels, there is every indication of the length of the shoot increasing; the ore from it will all, however, require crushing and concentrating before smelting.

The gold values in this mine have always been a considerable factor, amounting to something like 5dwts. to the ton of ore treated; how this, which practically all comes from above the 200 feet level, compares with the 400 feet is only known to the company, but it is probable that a considerable diminution will have taken place, whilst below the circulation of the ground waters it will probably be carried only in negligable quantities.

In the upper levels the lode is enclosed by massive hornblende country upon the south, and garnet rock upon the north, whilst in the deeper levels the south wall is a fine grained amphibolite, and that upon the north a coarse crystalline hornblende rock.

It is crossed by an acid dyke, which intersects it between the Nos. 1 and 2 shoots without causing any deflection of the line, whilst this body is apparently decreasing in width with depth.

In sinking the main shaft from the 300 feet to 400 feet level a fissure was encountered from which so heavy a flow of water was emitted that the workings were flooded, and when this was overcome so far as the levels were concerned, it was found to be quite impossible to proceed with the shaft sinking in this fracture zone, therefore a winze was sunk in the solid country about 50 feet farther to the westward and the level driven back under it which allowed large pumps to be installed before the fissures were tapped and the shaft drained.

Table showing the Yield of the Mt. Cattlin Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold therefrom per ton.	Copper therefrom.
		tons.	ozs.	%
1902	Mt. Cattlin, M.L. 15	2.50	..	20.00
1903	Do. do.	18.63	0.03	14.76
1904	Do. do.	78.29	0.25	12.51
1905	Do. do.	382.14	0.17	5.00
1906	Phillips Gold and Copper Co., Ltd., M.L. 15	1,263.76	0.30	6.43
1907	Mt. Cattlin Copper Mining Co., Ltd., M.L. 15	6,357.67	0.23	5.07
	Total	**8,102.99**	**0.24**	**5.33**

Average value of ore, £5 12s. 6d. per ton.

Mt. Cattlin West, M.L. 219.—Upon this lease, which has been previously known as the Zealandia, Puzzle and Puzzler, and which lies about ¼ mile to the south-west of the Mt. Cattlin, a cupriferous dyke, striking in a north-westerly direction and dips at a high angle to the north-east, has been developed to a depth of 105 feet by an underlay shaft, sunk upon the hanging wall side of a large formation.

In this shaft, the ground water level was originally cut at a depth of 75 feet, but since the Cattlin has been unwatered at the lower levels, this has now receded to the 100 feet level.

At the 45 feet level the vein which was much broken, has been driven on in an easterly direction for a distance of 25 feet, whilst at the 70 feet level the formation has been crosscut in a north-easterly direction for a distance of 27 feet.

At the 100 feet level, a crosscut has been driven north-easterly 40 feet, a winze sunk 14 feet and a rise put up 18 feet, upon a rich portion of the lode, which was at this point 10 feet in width. A level has also been driven 40 feet in a westerly direction, upon a small vein of ore on the hanging wall side of the formation.

Some very rich bunches were worked in the carbonate zone, which extended to a depth of 60 feet, below which, however, the sulphides, as a general rule, are more generally disseminated throughout the formation, although zones of enrichment also occur particularly upon the walls, which latter are at present the only portions that are of high enough grade to smelt without concentration.

Table showing the Yield of the Mt. Cattlin West Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Zealandia, M.L. 46	39.75	..	28.67
1903	Do. do.	19.11	..	9.26
1904	Puzzle, M.L. 189	32.94	..	14.29
1905	Puzzler, M.L. 219	9.86	..	14.09
1906	Puzzler, M.L. 219	2.58	..	13.56
1907	Mt. Cattlin West, M.L. 219 ..	22.78	.03	9.87
	Total	127.02	..	17.14

Average value of ore, £9 per ton.

The Copper Horseshoe, M.L. 244.—This lode which strikes in a north-easterly direction for a length of about 5 chains, is situated about 60 chains to the south-westward of the Mt. Cattlin.

It has been opened by a main shaft to a depth of 98 feet, in which the permanent water level was cut at 80 feet.

It is a small vein, which varies from 6 inches to 2 feet in thickness, and carried carbonates of copper in bunches for a length of 30 feet, which has been stoped up from a depth of 20 feet to the surface, the sulphides beginning to show at a depth of 25 feet, below which the country is very hard.

A total of 15 tons of ore has been raised from this mine, which averaged 13½ per cent. of copper, whch was valued at £104.

Marion Martin, M.L. 16.—This mine, which is situated in the greenstone area, near the north-western corner of the township, has been worked more or less consistently from 1901 to 1905, after which it passed into the hands of the Phillips River Gold and Copper Company, who raised a certain amount of ore in 1907, since which it has been let to tributers.

There are at least four lines of lode upon this lease, but although the ore in the oxidised zone was of good grade, the veins were small, whilst the parcel raised by the Company showed a considerable falling off in value from those previously treated.

For full particulars *see* the State Mining Engineer's reports.

Table showing the Yield of the Marion Martin Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Marion Martin, M.L. 16 ..	75.00	..	18.18
1903	Do. do.	138.95	..	15.02
1904	Do. do.	322.49	.02	16.04
1905	Do. do.	329.25	.03	13.46
1907	Phillips River Gold and Copper Co., Ltd., M.L. 16	566.61	.06	5.09
1908	Phillips River Gold and Copper Co., Ltd., M.L. 16	28.49	.02	11.12
		1,460.79	.04	11.46

Average value of ore, £7 per ton.

Sunset, M.L. 115.—This mine is situated at the north-western corner of the township of Ravensthorpe, and, although in the greenstone area, granite makes its appearance at the bottom level upon the northern side of the lode, which has been sunk upon to a depth of 130 feet, one hundred feet of which is by shaft and the last thirty feet by winze.

The lode at the western end strikes west-north-west, but turns more to the south-east at the eastern end, whilst the dip, which is nearly vertical, is slightly inclined to the south in the upper workings, but turns over to the northward in the lower.

No water has been cut in this mine up to the present, but in spite of this fact, the oxidised zone only descended to a depth of

40 feet, below which chalcopyrite was met with, the matrix of the ore being ferruginous and siliceous in the upper levels and dense siliceous greenstone in the lower.

The shaft was sunk in ore all the way from the surface, the rich portion, which was from 35 to 40 feet in length and varied from 3 to 5 feet in width, has been stoped up from the 70 feet level, below which the matrix proved to be too hard to work profitably by hand.

At a depth of 100 feet there is a bunch of ore 10 feet in width, which great size is apparently due to the junctioning of a branch vein, which joins it from the southward, whilst in the level which has been driven for a distance of 15 feet east and 8 feet west, the entire formation is only 8 feet in width.

At a depth of 60 feet, a level has been driven for a distance of 50 feet in a south-easterly direction to another shaft, from which a portion of the vein has been worked up from a depth of 50 feet, which averaged 4 feet in width and carried rich bunches of carbonates of copper. There is a considerable quantity of low grade ore in the dump.

Table showing the Yield of the Sunset Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1903	Sunset, M. L. 115	65.36	..	12.85
1904	Do. do.	286.30	..	10.21
1905	Do. do.	87.00	..	11.09
1906	Do. do.	39.10	..	7.24
1907	Do. do.	29.68	..	7.51
	Total	507.44	..	10.31

Average value of ore, £6 10s. per ton.

Surprise, M.L. 114.—This mine adjoins the Sunset upon the west, and is possibly the same line of contact fissure, although it has, so far, not been traced. The lode, which did not outcrop at the surface, has an east and west course, with a dip of about 75 degrees to the northward, consisting, when first cut at a depth of 3 feet, of 20 inches of ferruginous carbonate of copper and three feet of weathered formation, which diminishes in size with depth, but becomes more defined and has a good footwall.

A main shaft has been sunk to a depth of about 80 feet upon the underlay, from which depth the lode has been followed by a winze to a further depth of about 40 feet, in which the ore body is about 8 feet in width, containing chalcopyrite in too disseminated a state to be smelted without concentration.

At a distance of 120 feet farther to the westward another shaft has been sunk upon the same vein which here carried rich, but small bunches of carbonate ore.

Like the Sunset, the country was extremely hard in the lower levels, and in consequence did not pay, and, therefore, since practically all the marketable ore in sight has been worked out, this mine is now at a standstill.

Table showing the Yield of the Surprise Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Surprise, M.L. 114	5.50	..	18.18
1904	Do. do.	153.96	..	15.44
1905	Do. do.	61.42	..	14.96
1906	Do. do.	175.19	..	9.07
1907	Do. do.	20.39	..	34.04
	Total	466.46	..	12.17

Average value of ore, £8 per ton.

The Eastern Group.—This group of mines is situated about three miles to the north-eastward of Ravensthorpe, close to a low range of foot hills, which run in a north-westerly direction, known as Mt. McMahon.

These mines follow on east and west belt of country, which starts close to the range where the rocks are of a highly schistose character. containing parallel zones or beds, in which ferruginous concentration has taken place.

The central and western portions of this group are in greenstone country, the rocks of which have been intruded into the granite area.

The lodes in the schistose area have usually a north-westerly course, with a south-westerly underlay and are of considerable longitudinal extent, whilst those in the greenstone area are mostly short, extremely irregular, and most usually occur at or near the contact of the greenstones with the granite.

About 3,700 tons of 12 per cent. copper have been raised from these mines, but at the present time very little work is being carried on since the Phillips River Gold and Copper Company have closed down the Mt. Benson, because they failed to locate the lode at a depth by boring, whilst upon the other lease little more can be done without machinery, for which the necessary capital is not at present forthcoming.

Table showing the Yield of the Mines of the Eastern Group—Ravensthorpe Centre.

Year.	Name and Number of Lease.	Ore treated.	Gold therefrom.	Copper therefrom.
		tons.	ozs.	tons.
1903-7	Ballarat (Emily Hale), M.L. 205	252.58	..	34.81
1904-8	Birthday (Duke of York, Mt. McMahon), M.L. 259 ..	18.11	..	2.22
1904-7	Contest (Federal), M.L. 196 ..	24.36	0.21	2.88
1901-7	Last Chance, M.L. 116 ..	874.99	5.31	140.20
1906	Last Chance Ext., M.L. 227	2.55	..	0.34
1901-7	Last Chance Prop., M.L. 200	278.94	..	32.00
1901-7	Mary, M.L. 7	795.74	9.47	109.70
1900-7	Mt. Benson (Kingston) M.L. 175	1,333.99	508.23	119.15
1904-7	Mt. Benson Ext. (Blue Ribbon) M.L. 195	34.12	11.88	3.49
1903-8	New Moon (Kilmore), M.L. 204	125.33	0.70	17.47
1903	Nil Desperandum, M.L. 133 ..	4.26	..	0.34
1907	Our Selection, M.L. 276 ..	10.89	..	0.98
1906	Who Can Tell, M.L. 221 ..	1.45	..	0.16
	Total	**3,757.31**	**553.80**	**463.74**

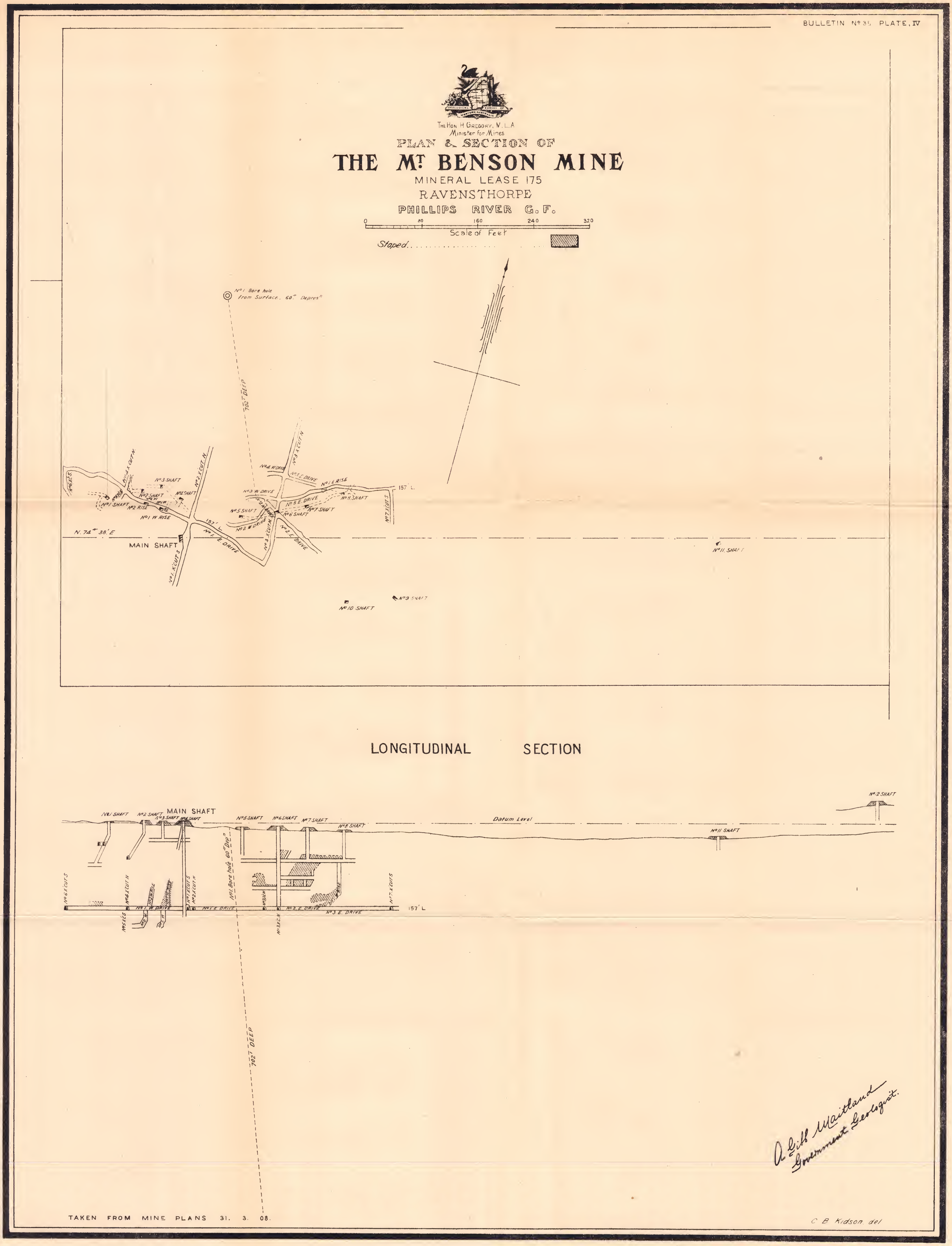
Mt. Benson Copper Mine, M.L. 175 (Plate IV.).—This mine which was originally a portion of the Kingston mine, is owned by the Phillips River Gold and Copper Company, Limited, and is situated nearer the western end of this group of mines at the contact of the greenstones with the granite.

No official report exists upon this mine, and since it is at present closed down, no examination can be made, a plan of the workings is, however, attached, which will give an idea of their extent.

Table showing the Yield of the Mt. Benson Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1900	Kingston, M.L. 10	11.00	0.47	31.50
1903	Mt. Benson, M.L. 175 ..	106.20	..	14.14
1904	Do. do.	120.94	0. 2	11.17
1905	Do. do.	364.68	0.48	12.13
1906	Do. do.	13.37	..	5.83
1906	Phillips River Gold and Copper Co., Ltd., M.L. 175 ..	84.50	0.48	10.66
1907	Phillips River Gold and Copper Co., Ltd., M.L. 175 ..	633.30	0.27	5.26
	Total	**1,333.99**	**0.38**	**9.00**

Average value of ore, £7 per ton.



H. J. Pether, Government Lithographer, Perth. W. A.

Table showing the Yield of the Mt. Benson Extended Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1904	Blue Ribbon, M.L. 176 ..	11.35	.37	15.58
1905	Mt. Benson Extended, M.L. 195	2.55	0.50	16.50
1907	Do. do. ..	20.22	0.52	6.42
	Total	**34.12**	**0.47**	**10.23**

Mary Copper Mine, M.L. 7.—This lease is situated and adjoins the Mt. Benson upon the east, and upon it a considerable quantity of work has been done to a shallow depth on a series of copper lodes.

This mine is not being worked at present, whilst the most recent official report upon it appeared in the report on the Phillips River Goldfield by Mr. A. Montgomery, State Mining Engineer, issued by the Mines Department in 1903.

Table showing the Yield of the Mary Mine.

Year	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Mary, M.L. 7	32.90	..	22.19
1903	Do. do.	239.53	..	13.23
1904	Do. do.	327.24	0.02	13.91
1905	Do. do.	167.75	0.01	13.46
1907	Do. do.	27.32	..	8.05
	Total	**795.74**	..	**13.78**

Average value of ore, £4 2s. 0d. per ton.

Ballarat Copper Mine, M.L. 205.—This property, which is situated about half a mile south-east of the Mt. Benson, and west of the Last Chance Proprietary, includes the Emily Hale, M.L. 124, upon which lease the workings are located.

The lode has a general north and south strike with an underlay to the westward, its dip being at an angle of 45 degrees down to a vertical depth of 40 feet from which it pinches, and is followed down by the shaft for 20 feet, when it again assumes its old grade, and has been followed upon the underlay for a further depth of 50 feet.

At the bottom of this underlay it has been driven upon for a distance of 45 feet in a northerly direction, the lode consisting of sulphide ore about 4 feet in width in a hard greenstone rock, there being no defined walls until near the face, when the lode takes a turn to the north-west following the foliation of the rocks.

South from the shaft the lode is broken, but a crosscut 15 feet in length encountered another vein which followed a north-westerly course. This vein, although small, has been driven upon for a distance of 20 feet, in which it shows well defined walls and dips at a steep angle to the westward.

All the stoping has been done at and above the 65 feet level, which has been driven upon the vein for a distance of 90 feet south and 100 feet north. From the south drive a body of sulphide ore from 2 to 6 feet in thickness has been underhand stoped for a length of 40 feet to a depth of 15 feet and stoped up for 25 feet. The carbonate ore has been worked from the surface down to the 40 feet level, or about 60 feet on the underlay for a length of 40 feet, the ore body averaging about 3 feet in thickness, but it is not well defined.

The lode has been traced at the surface by trenches in a southerly direction for a distance of 132 feet, whilst in a pot hole, about 100 feet to the north-east, a vein about 3 feet in width is exposed, which should junction with the first-mentioned near the main shaft.

The water level was originally cut at a depth of 65 feet, while the sulphides came in, but since the Mt. Benson deeper levels were driven this mine has become quite free of water.

Table showing the Yield of the Ballarat Mine.

Year.	Name and number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1903	Emily Hale, M.L. 24 ..	51.40	..	15.93
1904	Do. do.	14.53	..	14.04
1905	Do. do.	29.56	..	17.66
1906	Do. do.	36.78	..	16.25
1906	Ballarat, M.L. 205	54.81	..	13.93
1907	Do. do.	65.50	..	9.00
	Total	252.58	..	13.78

Average value of ore, £10 per ton.

The Kilmore, now *New Moon,* M. L. 204.—This lease is situated upon the south side of this belt, about half a mile south-east of the Mt. Benson Mine, and adjoining the Ballarat upon the south-west.

The workings consist of a number of shafts sunk upon an ore channel to a depth of 40 feet at the contact of the greenstones, with the granite in which the ore occurs in a number of small rich veins.

At the bottom level the sulphides begin to make their appearance, but have not paid to work so far as the country is hard.

In the oxidised zone the ore channel consists of 20 feet schistose material 13 feet in width, the ore being carbonate of copper with oxide of iron.

Altogether rather above 125 tons of 14 per cent. ore have been raised, valued at £1,089.

Table showing the Yield of the Kilmore Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1903	Kilmore, M.L. 119	31.92	..	17.00
1904	Do. do.	29.77	..	13.20
1905	Do. do.	11.09	..	12.26
1906	Do. M.L. 204	23.71	..	10.67
1907	Do. do.	21.80	0.70	14.17
1908	Do. do.	7.04	..	16.47
	Total	125.33	..	13.93

Average value of ore, £8 per ton.

Last Chance, M.L. 116.—This the easternmost lease of this group which is situated in the schistose area close to the base of a steep hill ridge, which lies parallel to the Ravensthorpe Range.

The lode, which has a course of a little north of west, dips at an angle of 75 degrees to the south-westward, has been sunk on to a depth of 120 feet; very little work has been done below the water level, which is about 65 feet, since the ground is extremely hard, and the ore, which is chalcopyrite, being disseminated throughout the lode mass thus requiring concentration.

Above the water level the lode has been driven upon for a length of 400 feet, where it is well defined with good walls, and averages from 3 to 4 feet in width, whilst from this level several stopes have been worked up to the surface, from which about 875 tons of 16 per cent. ore have been mined.

Table showing the Yield of the Last Chance Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Last Chance, M.L. 116 ..	13.50	..	27.77
1903	Do. do.	150.71	..	17.03
1904	Do. do.	374.43	0.01	15.65
1905	Do. do.	75.58	0.01	16.14
1906	Do. do.	158.18	..	16.72
1907	Do. do.	102.59	..	13.16
	Total	874.99	..	15.02

Average value of ore, £9 12s. 6d. per ton.

Last Chance Proprietary, M.L. 120.—This mine is situated westward of the Last Chance, just within the schistose area, but close to its contact with the granite.

The lode, which has a course a little to the west of north, with a dip of about 70 degrees to the westward, has been sunk upon to a depth of 125 feet, from which level a winze has been sunk for a further depth of 90 feet upon an ore body, which pitches to the southward, consisting of quartz, chalcopyrite, and marcasite, with a little covellite coating about 3 feet in width.

In the 65 feet level, from above which most of the ore, consisting of carbonates, has been raised, the lode is 3 feet in width, and is enclosed between two well-defined walls in schistose country.

Table showing the Yield of the Last Chance Proprietary Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Last Chance Prop. M.L. 120	3.50	..	14.30
1902	Do. do. ..	12.00	..	14.58
1903	Do. do. ..	6.49	..	11.00
1904	Do. do. ..	12.88	..	12.20
1905	Do. do. ..	17.32	..	13.16
1906	Do. do. ..	84.49	..	13.14
1907	Do. do. ..	136.24	..	10.30
	Total	272.94	..	11.72

Average value of ore, £9 per ton.

THE MOUNT DESMOND CENTRE.

This group, or more correctly speaking, line of mines, is situated in a granitic belt of country close to its contact, with the greenstones which lie at the base and upon the western side of the Ravensthorpe Range.

These rocks, which are often schistose at the surface and always massive below the water level, are traversed by two series of large dykes, the first of which usually follows a north-westerly course and are of a basic type, whilst the other, which are acidic, intersect the former in a north-easterly direction.

The ore occurs in veins, bunches or disseminations through a schistose greenstone intermixed with a considerable quantity of quartz, whilst in the lower levels this lode material becomes massive with a foliated structure.

These formations usually indicate their presence at the surface as a ferruginous outcrop the course of which is nearly north and south, in which copper, if present, usually only occurs as stains, whilst in some instances as much as 30 feet has been sunk before ore of any value was met with.

In the oxidised zone the ore usually consists of green and grey ore associated with a considerable quantity of oxide of iron and quartz, which passes almost directly into chalcopyrite and pyrites, there being no marked zone of secondary sulphide enrichment (except along a fracture in the lode), although the last-mentioned class of ore is certainly richer in the upper section of the sulphide zone. This is purely a copper mining district, the gold only occurring in appreciable quantities as the result of concentration in the oxidised zone below which in the solid country contaning sulphides there is too little to materially add to the value of the ore.

Although some of the best lodes of this field exist in this locality the returns do not compare as favourably with the others as might be expected; this, however, is easily accounted for by the fact that at the time when the recent rise in the market value of copper took place these mines were practically at a standstill, all available ore having been raised, whilst lower grade mines in other localities had a considerable amount of ore in reserve which previously could not be raised at a profit.

Most of the small mines in this district, like those in the others, are practically at a standstill, owing to the fact that all the high-grade ore in the oxidised zone has been worked out, whilst capital is necessary before further developments can be proceeded with below the water level.

It will be noticed from the following table that only a return of 241 ounces of fine gold is shown from the mines in this locality; this is decidedly incorrect, but may be due to the fact that returns of fine gold values from copper ore were not sent in, or the gold in the ore was not allowed for by the smelters.

Table showing the Yield of the various Mines in the Mt. Desmond District.

Year.	Name and Number of Lease.	Ore treated.	Gold therefrom.	Copper therefrom.
		tons.	ozs.	tons.
1904	British Flag M.L. 174 ..	33.14	18.28	6.05
1904	Diamond M.L. 185	29.39	2.16	6.35
1907	Diamond Central, M.L. 255 ..	3.01	..	0.45
1901–8	Elverdton, M.L. 95	3,787.96	33.00	506.68
1901–4	Elverdton South M.L. 168 ..	37.18	..	7.14
1903	Elverdton Welcome Stranger M.L. 139	5.31	..	0.85
1901–7	Fairlie, M.L. 266	24.98	..	4.91
1903–6	Great Oversight, M.L. 210 ..	107.83	2.55	11.82
1907–8	Ironclad, M.L. 275	15.11	3.64	3.25
1901	Marnoo, M.L. 104	4.25	..	0.88
1901–7	Mt. Desmond, M.L. 109 ..	1,484.78	162.40	173.72
1902–8	Mt. Garrity, M.L. 271 ..	48.71	..	9.65
1904–7	P.L.P., M.L. 199	179.54	10.91	29.00
1906	Resurrection, M.L. 234 ..	1.10	0.06	0.10
1904	Rio Tinto, M.L. 158	6.50	0.32	1.17
1901–7	Thistle and Shamrock, M.L. 257	101.95	8.40	17.54
	Total	**5.870.74**	**241.72**	**779.56**

Average rate of .04 ozs. of fine gold per ton and 13.28% of copper.

Mt. Garrity, M.L. 271.—This lease, which has been held off and on since 1902, is situated at the base of the range, about 2½ miles to the north-west of the Elverdton Mine, and upon it a considerable amount of prospecting has been done upon some small and irregular bodies of ore, but so far no defined lode has been discovered.

The rocks belong to the acidic series and have a marked foliation at the surface, the direction of which is north and south, whilst the ore appears to be associated with the usual basic dyke material and quartz.

Table showing the Yield of the Mt. Garrity Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1902	Mt. Garrity, M.L. 117 ..	12.50	..	26.00
1904	Mt. Garrity, M.L. 173 ..	15.01	..	21.38
1906	Blue Spec, M.L. 238	11.83	..	12.58
1907	Mt. Garrity, M.L. 271 ..	6.93	..	17.31
1908	Do. do.	2.44	..	17.21
	Total	**48.71**	..	**19.81**

Average value of ore, £11 per ton.

Great Oversight, M.L. 210.—This lease lies about half a mile to the southward of the Mt. Garrity, and upon it a basic dyke outcrops which is in all probability the northern extension of that exposed in the workings of the Rio Tinto Mine. This dyke is highly weathered at the surface and contains a considerable quantity of biotite which develops into a heavy black mica schist at a little depth below, then passing imperceptibly into foliated massive greenstone.

Upon either side of this dyke, which has a course a little west of north, is a copper vein; that upon the eastern side, which is the smaller of the two, has an underlay to the eastward and is said to have yielded some good ore. It has been sunk on to a depth of about 50 feet, the ore from the upper portion of the lode being in part ferruginous and in part siliceous, but both contained blue and green carbonate of copper, whilst at the bottom it is poor, consisting of a dark schist impregnated with copper pyrites.

The main workings are situated upon the western side of the dyke, where a vein of ore has been sunk on to a depth of 90 feet, in which it is proved to be from 6 feet to 8 feet in width and to underlay to the westward.

About 90 feet farther south another shaft has been sunk to a depth of 60 feet, whilst the lode at the surface has been traced by open cuts for a further distance of 30 feet in this direction.

Photo. H. W. B. Talbot. Neg. 412.

The Ironclad Mine.

In these workings the ore above water level (35 feet) was of the usual ferruginous carbonate of copper type in a siliceous matrix, but below it passed into schistose greenstone and quartz containing copper and iron pyrites disseminated throughout of too low a grade to smelt without concentration.

Table showing the Yield of the Great Oversight Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1903	Great Oversight, M.L. 154 ..	1.14	..	28.07
1904	Do. do. ..	33.41	0.04	15.00
1906	Great Oversight, M.L. 210 ..	42.34	0.02	10.41
1907	Do. do. ..	30.94	..	6.70
	Total	107.83	0.02	11.00

Average value of ore, £8 per ton.

Rio Tinto, M.L. 158.—About two miles to the northward of the Elverdton, and adjoining the Great Oversight on the south, are some old abandoned shafts that were sunk upon a clay flat in the year 1904, when $6\frac{1}{2}$ tons of ore were raised which yielded 18 per cent. of copper.

No lode outcrops in this locality, and the only indication of the presence of ore was some scattered fragments of carbonate of copper upon the surface, which led to prospecting by trenches, in one of which a vein was discovered which measured 3 feet in width, and had a strike of south-east with a dip to the eastward.

The country rock is granite, but the lode, like the others of this district, is a ferro-magnesian dyke in which some rich bunches of green and grey copper ore are said to have been met with below a depth of 20 feet, the upper section being poor, whilst at the bottom of the shaft, which is 40 feet in depth, the lode was driven upon in a northerly direction for a distance of 20 feet in a massive greenstone rock containing splashes of copper and iron pyrites.

Ironclad, M.L. 275.—This lease is the northernmost of the Elverdton group, and upon it is a lode having a north-east and south-south-west course with an almost vertical dip, which is being prospected and will in all probability prove to be of the same character as those in the Elverdton and Mt. Desmond, viz., a cupriferous ferro-magnesian dyke, but in this case since the country rock is basic schists this point cannot be definitely settled until further development has been done.

At the surface the ore body only gave indications of its presence as a ferruginous quartz vein with a few copper stains, and it was not until this had been sunk upon to a depth of 20 feet that any copper ore was encountered, whilst another 10 feet was

sunk before the ore proved to be of a high enough grade to be profitably worked.

At a depth of 60 feet a level has been driven for a distance of 60 feet south upon the lode, which contains a good vein of ore three feet in width for a length of 30 feet from the shaft, beyond which it becomes small.

This vein has been stoped up for some four to five feet above this level, which is the limit to which the good ore extended, but since this is apparently going down strongly under foot, it is possibly the top of a rich ore body. The formation containing this vein is greenstone schist carrying a little copper, but up to the time of inspection it had not been crosscut.

The ore above the water level is a semi-decomposed sulphide with a good deal of carbonate of copper staining, whilst below it it consists of both primary and secondary sulphides, of which 15 tons have been smelted returning 21.59 per cent. of copper.

In these workings the salt water was struck at a vertical depth of 35 feet which makes at the rate of 3,000 gallons in 24 hours.

At a distance of 160 feet south from the main shaft another shaft has been sunk to a depth of 40 feet upon a ferruginous quartz body, the vein of ore in which is about three feet in width and carried carbonates of copper in small quantities from the surface downwards.

To the northward of these workings is a large ironstone outcrop five chains in length, which follows a course north-west and south-east, and shows a section of 30 feet in thickness at a point where it is crossed by a gully. Upon this a shaft has been sunk to a depth of 30 feet, from which a parcel of iron ore (some of which was copper-stained) was sent to the smelters for flux, therefore this is possibly the cap of a copper lode.

Mt. Chester, M.L. 250.—This lease lies to the eastward of the Ironclad, upon the top and upper section of the western face of the Ravensthorpe Range, and within it a large manganese lode outcrops, which can be traced at the surface for a distance of 250 yards, its width at one place where crosscut being 20 feet.

With the object of testing this at a depth an adit level was driven for a distance of 424 feet into the hill face from a point about 90 feet below the outcrop.

This drive passed through a series of kaolinised schistose rocks, some of which are highly ferruginous, whilst from others almost all traces of iron have been removed by leaching; some of these are distinctly gritty to the touch through containing small particles of quartz, whilst others consist of almost pure kaolin.

These rocks have a well-defined lamination which strikes in a north-westerly and south-easterly direction and dips at an angle of from 70 to 75 degrees to the south-west, the whole being traversed by numerous irregular veins and bunches of oxide of iron (leaching channels), whilst strange to state, although one of the large well-

defined ferruginous outcrops (called ironstone lodes) exists at the surface upon the face of the hill between the manganese outcrop and the tunnel mouth, absolutely no sign of this other than the veins before referred to was cut in this drive. At a distance of 300 feet from the entrance the manganese lode was cut, at which point, although consisting of a body 20 feet in width from wall to wall, it is composed of two veins of a more powdery character than the ore at the surface, the largest of which is nine feet in width.

P. L. P., M. L. 199.—This mine is situated immediately to the northward and adjoins the Mt. Desmond, and upon it two distinct lines of lode have been worked, the first or eastern being the same as was prospected close to the northern boundary in that lease.

Upon this three shafts have been sunk, the deepest of which is 75 feet, and from it a level has been driven south at a depth of 65 feet for a distance of 45 feet, at which point the formation, which consists of a basic dyke 12 feet in width, has been crosscut in a westerly direction; this carries a little copper and iron pyrites throughout, whilst the more highly foliated portions at its contact with the granite upon either wall contain a good deal of chalcopyrite and covellite. This level has also been driven upon the other wall for a distance of 20 feet, at which point it connected with the southern shaft.

A few chains to the westward a well-defined dyke outcrops upon the western side of which a small but rich vein of copper ore has been followed down by a shaft to a depth of 74 feet, at which point a crosscut was driven to the eastward for a distance of six feet in formation carrying a little copper pyrites, but work was discontinued before the other wall was cut. Upon the eastern side of this dyke a little to the northward of this shaft another small vein of copper ore has been worked from an opencut and some shallow shafts.

Table showing the Yied of the P.L.P. Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1904	P.L.P., M.L. 199	7.43	0.10	14.00
1905	Do. do.	45.23	0.10	18.00
1906	Do. do.	58.19	0.03	19.43
1907	Do. do.	68.69	0.05	12.37
	Total	179.54	0.06	17.00

Average value of ore, £11 4s. per ton.

Mt. Desmond Copper Mine, M.L. 109 (Plate V.).—In this mine, which lies to the north-eastward of the Elverdton, the lode is

of a similar character to that worked in that mine, viz. : a foliated cupriferous basic dyke ; it is considerably larger in size, but so far has not proved to carry ore in such a concentrated form, with the exception of a length of 100 feet in the upper levels.

The course followed by this lode formation is generally north and south, with an underlay to the eastward, and this has now been driven upon at the 96 feet level for a length of 480 feet at the southern end, of which it strikes one of the main north-westerly dykes, the outcrop of which is plainly visible at the surface (see map).

Upon the south side of this dyke, a lode following the same course as that first mentioned has been prospected upon the Desmond and British Flag leases, and this is in all probability the continuation of the same fissure, but the exact relationship in which these two stand to one another cannot as yet be determined.

The Mt. Desmond lode was traced at the surface for a distance of 300 feet, the southern end of which, near the greenstone dyke, is highly siliceous, but about 200 feet farther north the cap of a rich ore body, 25 feet in length, was cut, which was of a highly ferruginous character, containing nice bunches of carbonate of copper.

This rich portion of the lode was worked to the 45 feet level, where it lengthened out to 125 feet, having throughout an average width of from 4 to 5 feet, whilst from the stopes above, the original owners obtained 230 tons of 13½ per cent. ore.

When this property was acquired by the Phillips River Gold and Copper Company, a vertical shaft was sunk to a depth of 250 feet at a point 250 feet north of the old workings, and from this the 96 feet level has been driven 350 feet south and 125 feet north, the ore body being cut 145 feet south of the shaft. Here it consisted of two sections of payable ore, containing chalcopyrite, corvellite, and pyrites, which have been stoped up to the 40 feet level, the first portion of which is 60 feet in length, when after ten feet of low grade material, the second is 30 feet in length.

The formation in this level is of considerable width, varying from 20 feet at the south end, up to 60 feet at the north, and consists, generally speaking, of a low grade, dark cupriferous greenstone, often schistose, and particularly so near its contact with the granite, which encloses it.

At the 196 feet, a level has been driven for a distance of 170 feet south, at which point it is connected with the 96 feet level by a winze, in which the downwards continuation of the rich vein worked in the upper levels is exposed, it being where passed through a body of high grade chalcopyrite of greater width than the winze.

From the stopes above, the 96 feet level and the winze below it, the present company has raised 1,256 tons of 11½ per cent. ore.

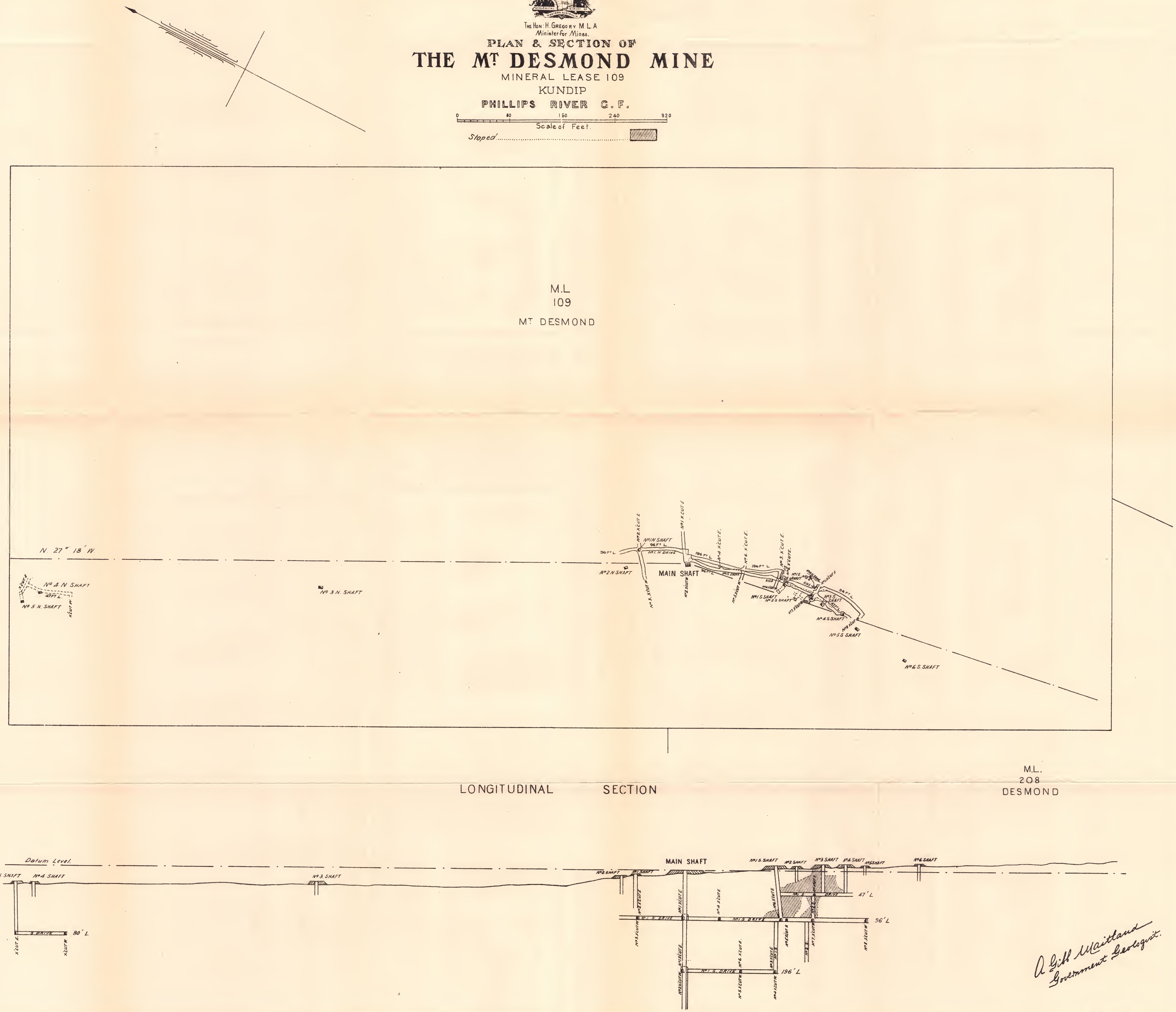
7,9

The Hon: H. Gregory M.L.A.
Minister for Mines.

PLAN & SECTION OF

THE Mt DESMOND MINE

MINERAL LEASE 109
KUNDIP
PHILLIPS RIVER G. F.



A. Gibb Maitland
Government Geologist.

TAKEN FROM MINE PLANS 30. 6. 08.

C. B. Kidson del.

H. J. Pether, Government Lithographer, Perth, W. A.

Owing to the fact that the water was up the mine, the bottom level could not be inspected, but to judge from the stone upon the dump, the lode consisted of a low grade pyritic and cupriferous massive greenstone, whilst from information furnished by the plan the formation would appear to be of even greater size in this than the level above.

Close to the northern boundary of this lease, the southern extension of the P.L.P. lode has been tested in this lease by a shaft 100 feet in depth and a crosscut east, in which the dyke body proved to be 30 feet in width and to consist of a massive cupriferous, greenstone body, which was driven upon in a southerly direction for a distance of 90 feet.

These workings were not inspected, but to judge from the stone at grass it is a low grade sulphide body, requiring concentration before smelting.

Table showing the Yield of the Mt. Desmond Copper Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Mt. Desmond, M.L. 109 ..	23.00	0.06	6.30
1903	Do. do. ..	35.47	..	15.20
1904	Do. do. ..	64.35	0.22	15.00
1905	Do. do. ..	76.05	0.30	14.00
1906	Mt. Desmond, Phillips River Gold and Copper Co., Ltd. M.L. 109	484.72	0.13	12.42
1907	Mt. Desmond, Phillips River Gold and Copper Co., Ltd., M.L. 109	801.19	0.07	10.32
	Total	1,484.78	0.11	11.70

Average value of ore, £11 per ton.

Elverdton Copper Mine, M.L. 95 (Plate VI.).—This mine, which is situated close to the western side of the Ravensthorpe Range, upon a ridge that forms the water parting between the basins of the Steere and the Jerdacartup Rivers, proved in its earliest stages to be of exceptional richness, so much so, in fact, that it was purchased from the original discoverers by the Phillips River Options Syndicate N.L., entirely out of the proceeds of the sale of ore raised during the short period over which they held the right of purchase. Subsequently, this Syndicate also acquired, equipped, and developed several other properties solely out of profits made in this mine, but unfortunately in so doing they neglected the only one of value, and in consequence, when the oxodised ore had been rooted out down to the water level, no funds were available for the purchase of plant, or for further development.

This property was then purchased by the Phillips River Gold and Copper Company, who have now developed a fine ore body down to the 350 feet level. The workings in this mine may be divided into two groups, viz. : the shallow and the deep, the former of which were carried out by the old syndicate and are confined practically to the oxidised zone, whilst the latter by the present Company are entirely below the ground water level in the sulphide zone.

In the upper workings, which extend for a length of 680 feet (including those upon the South Elverdton, M.L. 168), the lode may be said to contain three bonanzas, the northern or principal one, which was 180 feet in length, and averaged about 6 feet in width. has been stoped out bodily to a depth of 87 feet, the ore being a high grade ferruginous carbonate of copper, siliceous in part. The second or middle, which lies to the southward of a fault, which crosses the lode, did not outcrop, but was worked up from the 42 feet level to within 8 feet of the surface for a length of from 70 to 110 feet, whilst the third or southern patch, which is in the South Elverdton lease, was worked above the 40 feet level, when the ore consisted of nodules of green carbonate of copper, contained in a kaolin matrix.

From these workings upon the Elverdton proper, 3,054 tons of 15 per cent. ore were raised and from the South Elverdton 37 tons of 19 per cent. ore, but in spite of the fact that in the early days of this mine, the ore in the oxidised zone carried as much as 6dwts. of gold per ton; no returns appeared until quite recently.

Immediately below the 87 feet level, the lode consists of a siliceous schistose greenstone, through which copper and iron pyrites are disseminated, but it also contained two lenticular bunches of ore of higher grade (chalcopyrite, with covellite coatings), which were stoped up from the 130 feet to the 87 feet level, one of which was 60 feet in length and the other 20 feet.

At the 130 feet level, which has been driven for a distance of 200 feet north of the main shaft and 45 feet south, the lode was very siliceous and carried low values.

The main shaft was then carried down to the 250 feet level and a crosscut driven east 15 feet, where it cut the ore body which here consists of a foliated greenstone, containing quartz chalcopyrite and pryrites in bands. This was driven upon in a northerly direction for a distance of 30 feet, when all signs of ore were lost, however what was supposed to be the line of fissure was followed for a distance of 100 feet, but since no ore was met with, a bore hole was put in for a distance of 15 feet to the eastward, which proved the existence of a fine body of chalcopyrite in that direction. A crosscut was then driven and the lode followed back in the direction of the main shaft to the point where it was originally lost, where it was discovered that a pinch had taken place. This level was then con-

BULLETIN Nº 35 PLATE VI.

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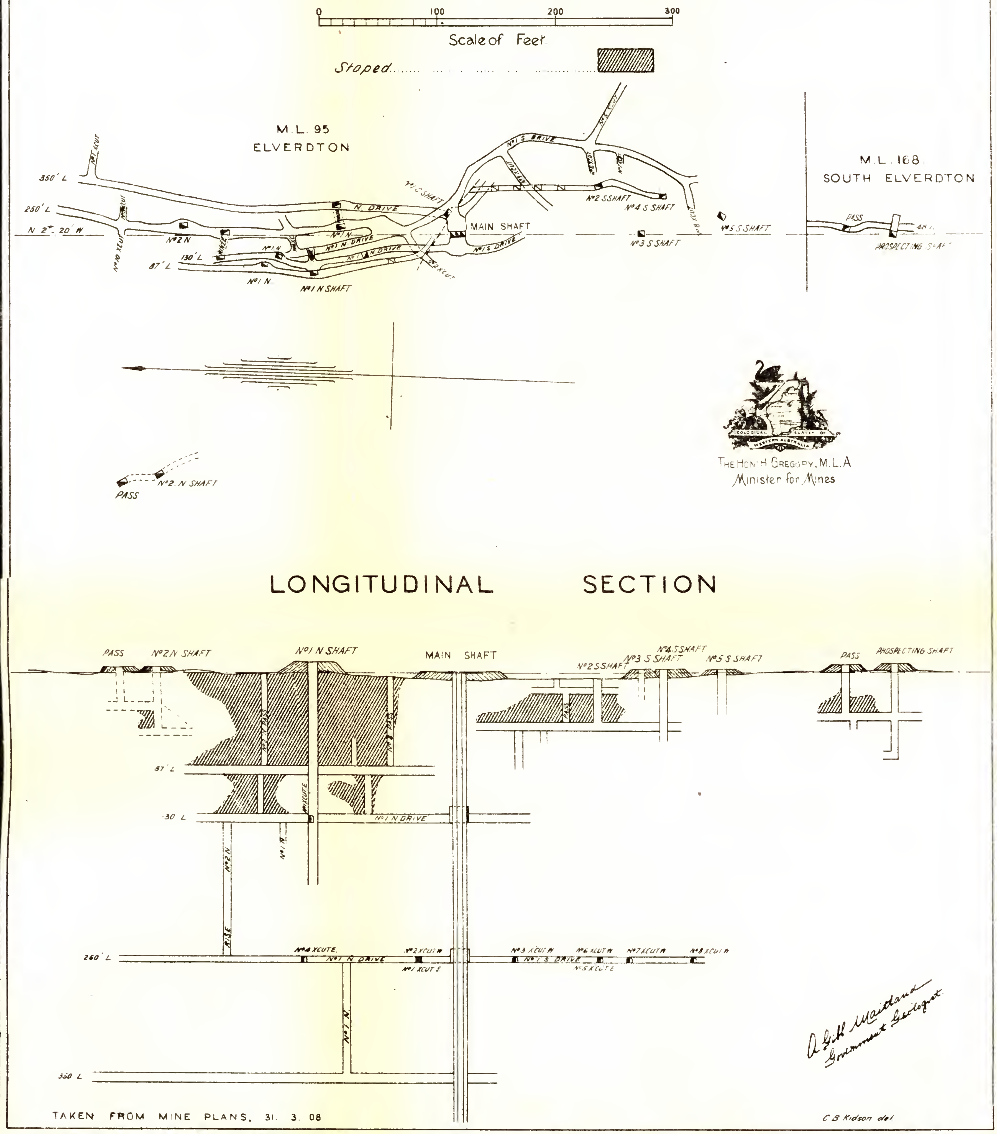
BULLETIN No 35 PLATE VI.

PLAN & SECTION OF THE ELVERDTON MINE

MINERAL LEASE 95

KUNDIP

PHILLIPS RIVER G.F.



H J Pether, Government Lithographer, Perth, W A

tinued for a distance of 200 feet farther north, the last 60 feet of which was in very low grade ore, whilst the balance of 270 feet averaged about 3 feet in width of 9 per cent. ore.

From this level at a point 190 feet north of the main shaft, a rise has been put up 60 feet in which the ore vein averaged 4 feet in width, worth 13 per cent. of copper.

Close to the main shaft a fault is exposed, which has apparently deflected the course of the lode to the south-eastward for a distance of 90 feet, after which it falls back upon its original strike, which has been further driven on for 150 feet. In this section of this level the ore values are for the most part low, with the exception of one point, where along a line of fracture a considerable amount of secondary sulphide enrichment has apparently taken place.

At the 350 feet level, the lode has been driven upon in a northerly direction for a distance of 300 feet, in which the ore body averages about 4 feet in width, and has a value of about 5 per cent. of copper per ton, thus showing an increased length and width, but a decreased value from the level above, the latter being probably due to the fact that less secondary enrichment has taken place and therefore this may be taken to represent more nearly the permanent value.

At a point 100 feet north of the main shaft, a rise has been put up to the 250 feet level in which the vein of ore averaged 2 feet 6 inches in width and assayed 9 per cent. Although the gold values carried in the upper workings are not recorded, they are stated to have been about 6dwts. per ton; these decreased to 3dwts. at the 250 feet level and 2dwts. at the 350 feet level, thus clearly demonstrating that the occurrence of this metal in appreciable quantities was due to secondary enrichment, and, therefore, the future value of this lode will probably consist of copper only. The general course of the lode is north and south, with a dip to the eastward of about 80 degrees; it is a cupriferous dyke, occurring in lenticular masses in a granitic country, the richest portions having so far been met with upon the footwall or western contact.

This dyke does not give any indication of its presence at the surface, whilst in the upper levels it is too highly decomposed to determine its character; below the water level, however, it assumes the appearance of a schistose greenstone, containing large quantities of quartz, whilst in the deeper workings it becomes massive.

The ore in the upper workings was the usual ferruginous carbonate of copper, associated with a considerable quantity of quartz, whilst below the water level it changes directly into chalcopyrite and pyrite in a foliated greenstone matrix with some quartz, the only indication of secondary sulphide enrichment being along cross fracture zones, where incrustations of covellite often occur upon the yellow ore.

Table showing the Yield of the Elverdton Copper Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Elverdton, M.L. 95	557.00	..	28.40
1903	Elverdton, Phillips River Options Syndicate, N.L., M.L. 95 ..	527.88	..	12.05
1904	Elverdton, Phillips River Options Syndicate, N.L., M.L. 95 ..	1,223.72	..	12.42
1905	Elverdton, Phillips River Options Syndicate, N.L., M.L. 95 ..	443.42	0.01	13.85
1906	Elverdton, Phillips River Options Syndicate, N.L., M.L. 95 ..	172.40	..	10.81
1907	Elverdton, Phillips River Options Syndicate, N.L. M.L. 95 ..	130.00	..	4.38
1907	Elverdton, Phillips River Gold and Copper Co., Ltd., M.L. 95	541.97	0.02	5.76
To June, 1908	Elverdton, Phillips River Gold and Copper Co., Ltd., M.L. 95	191.56	..	8.24
	Total	**3,787·96**	..	**13·32**

Average value of ore, £8 per ton.

Thistle and Shamrock, M.L. 257.—This lease, which has previously been known as the Welcome Stranger, C.D.C., and Addie, is situated at a short distance to the south-eastward of Elverdton, and upon it a lode which strikes in a north and south direction with a vertical dip, has been sunk upon to a depth of 80 feet (water level). It is from 2 to 3 feet in width, and lies between a greenstone dyke upon the west and granite country upon the east, and in it no payable ore was cut until a depth of 20 feet was reached, when a vein of from 6 inches to 1 foot 6 inches of high class carbonates was encountered, which was followed down. About 60 feet further north, a shaft has been sunk to a depth of 74 feet, at which level the lode has been driven on for a length of 80 feet, connecting with the first mentioned shaft.

The ore is of the usual ferruginous oxi-carbonate of copper siliceous in part, whilst at the bottom of the main shaft the sulphides begin to make their appearance.

Table showing the Yield of the Thistle and the Shamrock Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Welcome Stranger, M.L. 87 ..	4.00	..	22.00
1903	Welcome Stranger, M.L. 167	9.85	..	15.00
1904	Do. do. ..	2.92	0.24	12.00
1904	C.D.C., M.L. 186	18.43	0.17	13.67
1905	Do. do.	18.07	0.03	17.32
1906	Addie, M.L. 232	5.13	..	19.68
1907	Thistle and Shamrock, M.L. 257	34.75	0.02	17.44
To June, 1908	Do. do. ..	8.80	0.34	24
	Total	**101.95**	**0.08**	**17.20**

Average value of ore, £10 12s. 6d.

Fairlie, M.L. 266.—This property, which has been worked off and on since 1901, under the names of Mountain View, O.K., and Fairlie, lies higher up the range to the eastward of the last mentioned.

There are two cupriferous greenstone dykes enclosed in granitic country upon this lease, the western of which has a north and south course and can be traced for a length of 100 feet at the surface. The ore is of a high quality and occurs in a vein about 1 foot 6 inches in width, which has been sunk on to a depth of 75 feet and driven upon north and south for a distance of 80 feet, whilst all the ore has been stoped up from the 60 feet level.

Upon the eastern lode the north shaft has been sunk to a depth of 52 feet with a drive 27 feet, in which the cupriferous greenstone dyke has been crosscut, proving to be 13 feet in width, with upon the eastern wall a vein 2 feet 6 inches thick of ferruginous material, containing bunches of carbonate of copper.

Table showing the Yield of the Fairlie Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Mountain View, M.L. 107 ..	9.50	..	28.84
1905	O.K., M.L. 188	6.67	..	15.00
1906	Fairlie, M.L. 266	0.84	..	15.48
1907	Do. do.	7.97	..	13.00
	Total	24.98	..	19.66

Average value of ore per ton £14.

THE KUNDIP CENTRE.

This group of leases is situated to the northward of the township of Kundip, which is about 20 miles from Hopetoun and 12 miles from Ravensthorpe. It is the southern extension of the Mt. Desmond belt, which follows the Steere Valley upon the south-western face of the Ravensthorpe Range; this particular section being about one mile in width and three miles in length.

The rocks forming this belt are for the most part schistose greenstone, leached and kaolinised in part, but at the north end, upon the Mt. Stennett lease, massive greenstones form the country, whilst upon the western side of the Steere River, schistose granite is met with upon the Ard Patrick lease.

The directions of the lodes vary considerably, but may be divided roughly into two groups; the first of these, which has a more or less north and south strike, following the foliation of the rocks, dips to the eastward, and may be called normal lodes, whilst the second, which has a more or less east and west course, coincides with

the jointing planes dipping to the southward, and they may be called cross lodes.

Of these, both the normal and the cross series of lodes carry both gold and copper in the greenstone area, whilst the siliceous lodes in the granitic or kaolinised area are for the most part aurifrous only.

From the surface downwards to a depth of from 10 to 40 feet these lodes are almost destitute of copper, but below this to the water level (which varies with the elevation of the surface), carbonates and oxides are met with in the form of pipe-like zones, which in the normal lodes are inclined upon the fissure plane to the south, and in the cross fissures to the eastward.

In this latter class of fissures the copper ore appears to be richest along those lines at which the lode channel has intersected rocks of a more highly basic character, and in consequence the inclination of these zones is usually coincident with the foliation planes, upon which spur veins occasionally strike off.

Near the water level the sulphides make their appearance; the chalcopyrite when in a semi-decomposed condition being often coated with covellite, which is the only indication of secondary sulphides enrichment.

The lode matter generally appears to consist of a weathered basic intrusive rock, highly ferruginous and siliceous in part, which becomes pyritic below the water level, and this as a rule carries gold in greater or less quantities, also traces of copper; since, however, little work has been carried on as yet in the sulphide zone, the precise character of the ore has not been determined.

The siliceous gold lodes in the acidic and kaolin series as a rule dip at a low angle to the south, they do not all outcrop at the surface, but occur in a more or less tabular form, sometimes as sheets of ferruginous quartz, but more often as a network of veins in a kaolin matrix.

The majority of lodes of this district have so far proved to be cupriferous gold veins, but are apparently changing at the water level into auriferous copper lodes, whilst in all probability in the primary sulphide zone the gold values will fall even still lower.

Up to the present time most of the ore has been hand-sorted for smelting purposes, the balance being treated in the batteries for gold by which process an extraction of from 40 to 50 per cent. only is obtained, whilst the rich sands containing half the gold contents are too cupriferous to be amenable to cyanide extraction. These remarks do not apply to the ferruginous quartz veins which carry only gold, in which case if extraction is low it is solely due to faulty plant or management.

Upon the whole this district is a promising one, but lodes are valueless without capital to carry out the initial development and equipment, and since most of the payable ore has been scratched out from above the water level, the prospect is not too encouraging.

The following table gives the tonnage of ore treated either by smelting or battery, with the gold and copper returns therefrom from each productive lease in this district, whilst further details will be found accompanying the descriptions of the individual mines:—

Table showing the Yield of the various Mines in the Kundip District.

Year.	Name and Number of Lease.	Ore treated.	Gold therefrom.	Copper therefrom.
		tons.	ozs.	tons.
1906	Afric, G.L. 197	6.02	..	0.78
1907–8	Alice, G.L. 143	53.50	14.83	..
1906–7	Alice Mary, G.L. 99	28.02	3.83	0.96
1906–8	Ard Patrick, G.L. 107 ..	180.00	184.57	..
1902–7	Australia, M.L. 242	29.40	0.62	4.60
1906–8	Charmion, G.L. 132	47.50	28.81	..
1904–8	Christmas Gift, M.L. 184 ..	871.13	400.90	13.41
1901–8	Flag, G.L. 136–9	2,668.49	1,886.17	61.79
1908	Finnis, G.L. 126	0.05	19.77	..
1903–8	Gem, G.L. 65	2,648.85	1,330–44	..
1903–4	Gladstone Prop., G.L. 69 ..	..	91.12	..
1908	Great Britain, G.L. 294 ..	13.00	5.93	..
1900–8	Harbour View, M.L. 52 ..	6,155.08	2,513.00	131.69
1907–8	Harbour View North, G.L. 81	114.92	59.10	0.30
1904–7	Hecla, M.L. 206	28.86	..	3.55
1906–8	Hillsborough, G.L. 98 ..	413.80	516.31	3.84
1906–7	Kundip, G.L. 133	211.00	64.56	..
1906–7	Lily, G.L. 104	330.00	115.76	..
1904–8	Medic, G.L. 66	677.46	597.98	..
1902	Minna, G.L. 42	161.00	94.92	..
1904–8	Mosaic, M.L. 291	72.25	21.73	8.01
1901–7	Mt. Stennett, M.L. 108 ..	298.97	24.68	41.62
1902–7	Omaha, G.L. 73	344.94	369.72	1.37
1908	Queen of the Earth, G.L. 129	..	63.00	..
1907–8	Stowaway, G.L. 106	14.00	55.20	..
1906	Thrice Call, G.L. 114	8.75	10.10	..
1904–8	Two Boys, G.L. 74	1,142.12	1,568.77	..
1906	Try Again, G.L. 120	9.50	7.10	..
1906–8	Western Gem, G.L. 80 . ..	138.17	105.54	..
	Total	**16,666·78**	**10,154·46**	**271·92**

Average value of the ore treated, 0.61 ozs. of fine gold per ton and 1·62 % of copper.

Mount Stennett, M.L. 108.—At the extreme north end of the section of this mineral belt is an old copper mine known as the Mt. Stennett, called after the prospector and owner. It is situated about three miles north of Kundip at the base of the Ravensthorpe Range, and upon the eastern bank of the Steere River. The country at this point consists of a massive greenstone, probably a quartz diorite, which has broken into the foliated series composing the range.

The lode which is situated close to the southern boundary of the lease, has a nearly north and south course with a dip of one in four

to the eastward, whilst the greenstone in the immediate proximity to it is of a schistose character. It has been opened up by three underlay shafts from which it has been proved for a length of 110 feet. The central of these shafts is called the Whip shaft, and has been sunk upon the dip of the lode to a depth of 140 feet, the ground water being met with at a depth of 120 feet.

Immediately above this the lode has been driven upon in a southerly direction for a distance of 60 feet, whilst the patches of the richest ore from above this drive have been stoped to the surface The total width of the ore body at this level has not as yet been tested by crosscutting it from wall to wall. At a depth of 80 feet a level has been driven north for a distance of 30 feet, whilst from between it and the surface most of the ore has been stoped. These stopes are connected with the northern underlay shaft which is 45 feet in depth.

The average width of the lode in these workings was 3 feet 6 inches, the sulphides coming in at a depth of 80 feet, above which the ore consists of blue and green carbonate with oxides of copper, which was often highly ferruginous and always siliceous.

The southern shaft, which is 27 yards south of the whip shaft, has been sunk to a depth of 65 feet, from the bottom of which a level has been driven upon the lode for a distance of 30 feet north from above which the stone has been stoped for a height of 20 feet.

From this shaft at a depth of 25 feet, the lode has been driven on in a northerly direction for a distance of 30 feet, at which point the veins of ore which had varied from 12 to 30 inches petered out. The whole of the ore from above this level has been stoped out. South from this shaft, also at this level, the lode has been driven on for a distance of 12 feet, but in it the vein was too small to be payable.

The richest ore, which has averaged 13.6 per cent., appeared to occur in two pipe-like shoots, from which 298.87 tons have been raised, which represents practically all the ore of any value above the water level, since the balance still in sight is of too low grade to pay to raise by itself.

This mine has therefore been worked to a standstill, and will need capital to be expended upon further developments before any estimate as to the value of the lode in the sulphide zone can be formed.

About 10 chains north of the main group of workings another shaft has been sunk upon the underlay of a vein in the solid greenstone area to a depth of 95 feet (water level), and from the bottom of it a level has been driven 20 feet south, whilst another has been driven 12 feet in the same direction at a depth of 70 feet.

This lode is mostly ferruginous, with a little carbonate of copper to a depth of 30 feet, below which traces of sulphides make their appearance, the picked ore from which contains about 14 per cent. of copper and 10 dwts. of gold.

Table showing the Yield of the Mt. Stennet Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Mt. Stennett, M.L. 108 ..	32.00	0.12	19.00
1903	Do. do.	100.10	..	15.42
1904	Do. do.	65.56	0.29	13.21
1906	Do. do.	47.02	..	10.00
1907	Do. do.	54.29	0.03	12.58
	Total	298.97	0.08	13.92

This ore has realised on the average £9 5s. per ton.

Ard Patrick, G.M.L. 107.—This quartz reef has a strike north-east and south-west, and dips at an angle of about 45 degrees to the south-east, outcropping for a distance of four chains. At its eastern end it terminates suddenly upon coming in contact with a greenstone dyke; 36 feet northward of this point, however, a vein of quartz is seen outcropping which can be traced at the surface for a distance of one chain in a north-easterly direction, which is possibly the dislocated continuation of the same lode.

At the west end of this line an underlay shaft has been sunk to a depth of 30 feet, the stone in which averages about 2 feet 6 inches in width, and is said to be worth about 30dwts. At a point 34 yards farther east the reef has been sunk upon to a depth of 16 feet, where it varies from 1 foot 6 inches to 2 feet in width, and is said to be worth 8dwts., whilst nine yards still farther east there is a small pothole in which the vein is again exposed. A 30 feet vertical shaft, which cut the reef at that depth, has been sunk 29 yards farther east, but little work was done at this point owing to the fact that the reef pinched to a small size and was of little value. North of this 11 yards is the main underlay shaft, which has followed a good shoot of stone down from the surface for a distance of 110 feet, when it connects with the 60 feet level driven from the main vertical shaft which is situated 48 feet west.

This main shaft struck a heavy supply of salt water at a depth of 30 feet, but was continued down to a total depth of 70 feet. This water was at first difficult to handle, but after continuous bailing it has now been reduced to 3,000 gallons in the 24 hours.

Most of the reef above the 60 feet level in the underlay shaft has been stoped for a length of 55 feet, its average width being 2ft. 6in. Above this level the quartz is of a laminated character, and mostly white, being enclosed between two fairly well-defined walls of decomposed granite; the whole, however, is cut off at the eastern end by a weathered foliated greenstone dyke, upon the wall of which the stone makes a turn to the south-east, whilst at the west end of this level the vein pinches and becomes poor.

Below this level a sheet-like intrusion of greenstone (now weathered) makes its appearance, following the foot-wall of the lode, the surface of which is highly polished. At this level and also upon the foot-wall side of the reef some small veins of ferruginous manganese junction with the lode, which below this point become iron-stained and manganese-coated in places.

At the bottom level, which is 60 feet in vertical depth and 110 feet upon the underlay, the lode varies from 2 feet 6 inches to 3 feet in width, and presents a fairly solid appearance with a particularly well-defined foot-wall. In this level the shoot is about the same length as in the level above, and like it is cut off by the cross course at the east end and pinches in a similar manner at the west end. This block between the two levels is now being stoped.

About 36 feet north of the terminal point of outcrop of this reef at its eastern end where it is cut off by the greenstone bar, and upon the other side of the latter, a quartz vein of similar character has been opened up by a 30 feet underlay shaft with a drive at the bottom 15 feet east, in which the stone is 2 feet wide and is estimated to be worth 10dwts. The outcrop of this vein has been traced for the further distance of one chain east in a series of potholes.

This last-mentioned reef is in all probability the dislocated continuation of that first mentioned, it having been thrown off its course by faulting along the dyke fissure, since there is no indication at the surface of any other vein upon the opposite side of it; below ground, however, the indications point to the throw being in the other direction, therefore this question can only be satisfactorily settled by crosscutting the dyke and driving upon its eastern side.

The stone raised is carted a distance of about two miles to a battery where it is crushed, but since there are no means for sands treatment the 7dwts. contained in the tailings are lost, which is a serious matter to the owners.

Up to the end of June, 1908, this mine has produced 180 tons of quartz, which has yielded 184.57ozs. of fine gold, which is at the rate of 1.02ozs. per ton, whilst if the 7dwts. lost in the tailings are added this brings the total value of the stone up to 1.37ozs. to the ton.

Table showing the Yield of the Ard Patrick Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1906	Ard Patrick, G.L. 107 ..	10.00	14.48	1.44
1907	Do. do. ..	121.50	117.41	0.97
Up to June, 1908	Do. do.	48.50	52.68	1.08
	Total	**180.00**	**184.57**	**1.02**

Third Call, G.M.L. 114.—This lease is situated upon the eastern or opposite bank of the Steere River to the Ard Patrick. A small ferruginous reef outcrops upon the face of a steep hill, which was sunk upon to a depth of 20 feet, whilst later on an adit level was driven lower down the hill connecting with the shaft bottom. From this in the year 1906, 8.75 tons of stone were raised, which yielded 10.10ozs. of fine gold by battery treatment.

Gladys, M.L. 159.—This mine is situated in the foliated greenstone area at the base of the Ravensthorpe Range two miles north of Kundip upon the eastern banks of the Steere River.

It was originally worked for copper, when some fairly high-grade ore occurring in bunches was discovered at the surface.

Two underlay shafts have been sunk to a depth of 30 feet upon the lode, which was from three to four feet in width, striking north-west and south-east and dipping to the south-west, the ore in which occurred in bunches of carbonate of copper with some glance.

Later on this area was again taken up as a gold lease, when a vertical shaft was sunk a little to the south-west of the old workings to a depth of 70 feet, and from this a crosscut was driven north-east, in which a small quartz reef was met with carrying a little gold and also a small copper vein, but neither of these was large enough to be payable.

Alice Mary, G.M.L. 99.—This lease lies upon the east side of the Christmas Gift, and nearly at the top of the spur; the lode strikes a little south of west and underlays to the southward at an angle of about 60 degrees in blocky greenstone schist.

An underlay shaft has been sunk to a depth of 100 feet, at the bottom of which a short level has been driven to the eastward, in which a small vein of ore is visible.

At its outcrop the lode appears as a ferruginous quartz, no sign of copper making its appearance in the first 10 feet from the surface, but at this point small veins of rich copper ore contained in a mullocky formation about 6 feet in width were encountered. These veins extended in an east and west direction for a length of 30 feet along the lode and downward for 20 feet. At a depth of 60 feet in the shaft another make of ore was cut upon the hanging-wall of the formation, which was from six to eight inches in thickness and 12 feet in length and continued down to the bottom of the shaft 40 feet. In this vein at a depth of 70 feet the ore passed from carbonates into olivenite and erythrite, of which some very pretty specimens were obtained. The vein is small but of high grade, and little prospecting has yet been done upon the lode.

Upon this lease several other small holes have been put down upon ferruginous outcrops, some of which have yielded good prospects for gold at the surface, but so far in no single instance have they carried values down.

From this lease 8.02 tons of ore yielded .96 tons of copper and .52 ounces of fine gold, and 20 tons crushed yielded 3.31 ounces of gold, the total value of which was £101.

Christmas Gift, M.L. 184.—This mine is situated in the foliated greenstone upon a spur of the Ravensthorpe Range, on the east side of the Steere River, about two miles north of the township of Kundip.

Upon this lease the outcrop of a ferruginous lode can be traced at the surface for a considerable distance, the cap of which gives good prospects for gold in places. It has a strike of nearly north and south with an underlay at a high angle to the eastward; it exhibits no signs of copper at the surface, the first indications of which were met with at a depth of 8 feet to 10 feet, but no ore of value was discovered until a depth of 20 feet was reached.

The lode is apparently a greenstone dyke of considerable width, between which and the country the richest copper ore occurs upon either wall, whilst the entire mass (the nature of which cannot be determined owing to its highly weathered character) contains small quantities, and also gold.

A considerable amount of development has been done upon it, a main shaft having been sunk to a depth of 100 feet, which is vertical for the first 40 feet, below which it follows the foot-wall of the formation upon the incline.

At the bottom of this shaft a crosscut has been driven a distance of 18 feet to the hanging-wall of the lode, there being a vein of copper ore upon either wall, whilst the intervening portion is composed of blocky weathered greenstone.

The hanging-wall vein has been driven on for a distance of 20 feet south, at which point the ore pinches out upon a hard bar, but the fissure has every indication of continuity.

In sinking the main shaft a very nice bunch of high-grade ore was cut upon the foot-wall at a depth of 70 feet.

At a depth of 50 feet the formation has been crosscut, at which point it measures 12 feet from wall to wall. In this a nice vein of ore was cut which was driven on in a northerly direction to the north shaft for a distance of 105 feet. In this level the richest ore occurred in zones the length of which near the main shaft was 40 feet, an average width of 4 feet of this has been stoped up for 30 feet.

South of the main shaft the level has been extended for a distance of 90 feet to the south shaft in which the vein is small and poor in the first section but further on opens out to an average size of 4 feet for a length of 40 feet, the ore being mostly stoped out to a height of 30 feet and at one point to the surface.

The formation has as yet only been crosscut at two points, viz., from the main shaft at the two levels, therefore its average size and character cannot be determined. The ore so far as proved, with the exception of the bunch cut upon the footwall at 70 feet in the main shaft, is confined to the hanging wall of the formation, but it is possible that prospecting will prove the existence of other veins or bunches upon the other side.

The footwall where exposed in the shaft is well defined, whilst the hanging wall with the exception of one or two places is of a more ragged character.

The copper ore, which consists of carbonates and oxides of copper associated with ferruginous gossan and quartz, carries gold in greater or less quantities, it being occasionally visible in the stone but the higher average values are usually contained in those portions of the vein which are not so rich in copper and are most highly siliceous, which stone is sent direct to the battery.

There appears to be a large body of low-grade ore in this mine which should pay well to crush and concentrate if facilities were upon the ground, but which under present conditions will not pay. Water has not yet been struck in this mine owing to its elevated position, but it is probable that it will be encountered in sinking in the course of another 50 feet when the sulphide ores will be met with.

Table showing the Yield of the Christmas Gift Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1904	Christmas Gift, M.L. 184	217.00	0.67	..
		12.16	..	18.99
1905	Do. do.	62.00	0.75	..
		15.81	..	12.01
1906	Do. do.	1.43	0.87	15.38
1907	Do. do.	287.00	0.43	..
		39.60	..	13.40
To June 1908	Do. do.	212.00	0.25	..
		24.13	0.67	15.25
	Total	871.13	0.47	1.54

Average value of ore received, £3 per ton.

Australia, M.L. 149.—This old abandoned lease is situated upon the western bank of the Steere River about 1½ miles north of Kundip. It has been held later under the name of the Lone Star, M.L. 242 but is better known under its original designation.

The lode strikes north-east and south-west with a dip of 1 in 2 to the south-east, and upon it an underlay shaft has been sunk to a depth of about 50 feet (water level). In this shaft the vein consists of ferruginous quartz with carbonate of copper and is said to average from 2ft. to 2ft. 6in. in width, the picked ore going up to 33 per cent., whilst the length of the vein was 25 feet.

Another shaft has been sunk to a vertical depth of 50ft. with the object of cutting the lode but in it only some small veins of ore are said to have been met with.

Table showing the Yield of the Australia or Lone Star Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1902	Australia, M.L. 149	4.50	..	22.22
1903	Do. do.	3.29	..	20.06
1904	Do. do. ..	8.69	0.06	21.17
1906	Lone Star, M.L. 242	3.90	0.03	10.77
1907	Do. do.	9.02	..	7.54
	Total	29.40	..	15.64

The ore realised on the average £9 per ton.

Gem, G.M.L. 65.—Upon this lease which lies immediately to the northward of the Two Boys, a portion of the same flat reef has been worked, whilst below it another parallel vein or more correctly speaking a series of small veins contained in a belt of decomposed rock was more recently discovered.

This body strikes in an east and west direction and has been followed down from the surface upon an angle of about 40 degrees for a distance of about 200 feet in a southerly direction.

At and near the surface this formation carried no values, whilst downwards for a distance of 70 feet it was poor, but at this depth it was intersected by a small ferruginous quartz vein which apparently has influenced the deposition of gold, for below it the values at once improve.

At the 80ft. level, in which the formation averages 4 feet in thickness, it was found to be payable for a length of 110 feet or from the main underlay shaft in an easterly direction to a point where it is suddenly cut off by a fault having a course north-northeast. Upon this fault a ferruginous body of stone was encountered dipping to the eastward at a high angle, which carries good values and is particularly rich at certain points where the lode material consists of dark coloured loose ferruginous sand.

This vein had been driven on for a distance of 20 feet in a northerly direction and was showing as a strong body in the face which yielded good prospects, whilst to the southward it appeared to split into two small veins.

The 80ft. level has also been driven in a westerly direction from the main shaft for a distance of 30 feet, but in this portion of the mine the formation did not carry high enough values to be payable. The next level is at 140ft. upon the underlay and has been driven in good stone for a distance of 70 feet east to the fault and 30 feet west, of which latter distance the first 15 feet only of the reef carried payable values.

From this level a winze has been sunk midway between the shaft and the fault in a south-easterly direction but was stopped by a dislocation of the country. In this winze a good section of the formation was visible, which here apparently consists of one small main ferruginous vein crossed at an angle by a series of small quartz stringers, the bulk of the mass being composed of highly kaolinized and leached schists, the footwall country being as a rule almost pure kaolin whilst the hanging wall, although similar, is of a more siliceous and gritty character. The main fissure shows signs of the passage of water which has in places deposited secondary silica in a tuffaceous form similar to that met with around hot springs.

At the bottom of the winze the fault has been penetrated for a few feet upon the other side of which no continuation of the vein was met with, whilst the rock although still an altered schist was not nearly so highly kaolinized as that upon the western side. This apparently indicates a drop of the formation lying to the west of this line of dislocation, and if this is the case it would be necessary to rise upon the eastern side in order to pick up the vein.

The main underlay shaft has been carried down from this level for a further depth of 60 feet upon the incline in which the formation presents a well-defined appearance and yields good prospects.

Upon the range to the eastward of these workings there are a series of banded jaspery quartzite, a portion of one of which is covered by this lease, and upon it a considerable amount of prospecting has been done at the surface, whilst lower down the hill a series of extensive adit levels have been driven into it upon white quartz veins in kaolin rock, but so far no payable values have been met with.

Table showing the Yield of the Gem Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1903	Gem, G.L. 57	8.00	24.30	3.03
1904	Gem, G.L. 65	17.50	6.63	0.39
1905	Do. do.	146.00	145.72	0.99
1906	Do. do.	524.00	460.99	0.88
1907	Do. do.	843.35	399.22	0.47
6 mths. of 1908	Do. do.	1,110.00	293.58	0.26
	Total	2,648.85	1,330.44	0.50

Two Boys, G.M.L. 74.—This mine, which is situated about 1½ miles north-east from the Township of Kundip, is upon the top of a spur which strikes off from the Ravensthorpe Range in a westerly direction.

The country in which the reef occurs is a belt of highly kaolinized schist which lies immediately upon the western side of the range. A considerable quantity of prospecting had been carried out in this locality consisting of shafts and adits in the kaolin rock, which was supposed to be an alluvial deposit, and it was in one of these that a small ferruginous leader extremely rich in gold was cut at a depth of 40 feet.

Upon following this leader it was found to open out into a flat reef of fair size, and although not nearly so rich as at the point where it was first cut it averaged over 2ozs. of gold per ton. This lode although described as a flat reef has in reality a decided dip to the south-east, in which direction it was found to rapidly increase in size, the inch or two expanding to 6 feet in quite a short distance.

The small vein was traced in a north-westerly direction in order to determine the reason for its non-appearance at the surface, the solution of which was found in the fact that the dip had changed into the opposite direction.

The ore body, which averaged about 3 feet 6 inches in thickness, is composed of a sintery quartz and ironstone, whilst in some places, owing either to chemical action or crushing, portions of it have been converted into a clear white sand rich in gold. It is not by any means a definite body, for portions of it often consist of a network of minor ferruginous veins in the kaolin country adjoining the main fissure. As a rule the roof or hangwall is of a more gritty (siliceous) character to the footwall and in consequence more pervious to the percolation of descending meteoric waters which in all probability played an important part in the deposition of the gold in this vein.

Workings upon a reef of this character have to be carried on more upon the system adopted in coal than that practised in gold mining, and in consequence they would be difficult to describe in detail; it will be sufficient, therefore, to state that it is worked by a series of vertical shafts, the deepest of which is 120 feet, and a series of levels, the deepest being 75 feet below the surface, in which the lode has been driven upon for a length of 300 feet. From between the upper levels the ore is being removed by a series of comparatively flat stopes, the grade of which is so slight that the broken stone will not gravitate but requires passing by hand the whole distance.

At the bottom workings in this mine the lode is cut by a greenstone dyke, but whether it terminates upon this or will be discovered upon the other side has not yet been determined.

As the general direction of the foliation of these schists in which this lode follows the joint planes strikes north-west and south-east, or at right angles to it, and since the belts of rock vary considerably in composition, as might be naturally expected the character of the ore body changes with it, as also do its gold values; for instance, when the roof consists of almost pure kaolin it increases in richness, whilst upon the other hand it becomes poorer when the overlying country is more siliceous.

Table showing the Yield of the Two Boys Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1904	Hill End, G.L. 67	12.00	9.83	0.82
1905	Do. do.	25.00	13.70	0.55
1905	Two Boys, G.L. 74	40.00	70.77	1.94
1906	Do. do.	340.00	8 9.18	2.61
1907	Do. do.	8.12	44.38	5.47
To June 1908	Do. do.	717.00	540.91	0.75
	Total	1,142.12	1,568.77	1.40

Hillsborough, G.M.L. 98.—This mine, which was originally taken up for gold, is situated a little to the westward, but upon the same spur of the Ravensthorpe Range as the Gem and the Two Boys.

The lode upon this property strikes in an easterly and westerly direction and underlays at an angle of about 70 degrees to the southward; this has been followed down by an inclined shaft to a depth of 95 feet, the ore body being from three to four feet in thickness to a depth of 75 feet, below which it opens out to a width of 18 feet. It consists of ferruginous quartz for the first 85 feet from the surface, but below this carbonates and oxides of copper make their appearance.

A vertical shaft has been sunk at a point 50 feet to the southward which cuts the lode at a depth of 120 feet (water level) and in a crosscut from it the ore body measured 20 feet from wall to wall for a length of 12 feet. From this a level has been driven west for a distance of 40 feet upon the footwall side of the formation, following a vein of ore three feet in width which has been stoped up and connected with the upper workings at the bottom of the underlay shaft.

At the end of this level the ore vein is suddenly cut out upon a hard bar of country but the fissure line apparently continues through it.

In an easterly direction a level has been driven in the footwall for a distance of 100 feet, but in it no ore was met with after leaving the plat a few feet, whilst at the face the rock in the ore channel has changed in character. Upon the hanging wall a level has also been driven in this direction for a distance of 40 feet, following a vein of ore the average width of which is two feet. Upon the eastern side of the plat the ore fills the entire width between the walls at the roof of the chamber but below it is replaced by a bar of country which rises from the floor, the only continuation in this direction being the small vein before mentioned upon the hanging wall side. Upon the

western side of the plat a little ore is contained all through the formation, but it only continues in this direction as the three-foot vein upon the footwall previously mentioned.

In the stopes above the plat and the western level which have been carried up to a height of 15 feet the ore fills the entire width of the lode channel and this body has now been followed up by a 20 feet rise connecting with the bottom of the underlay shaft.

At the bottom level the formation is contained between two well-defined walls 20 feet apart in foliated greenstone country, whilst the filling matter appears to be an altered diabasic rock. This carries copper ore either disseminated through it in small quantities or concentrated into veins upon either wall, whilst between the two shafts a large bunch fills the entire channel for a length of 12 feet.

Copper sulphide in small quantities is met with at the 120 feet level, whilst gold is often visible in both the stone and the ore.

Table showing the Yield of the Hillsborough Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1906	Hillsborough, G.L. 98 ..	61.00	1.62	..
1907	Do. do.	224.09	1.61	..
		70.57	..	4.35
1908	Do. do. ..	23.14	2.02	..
		35.00	0.19	3.32
	Total	413.80	1.24	0.93

This ore has realised on the average £5 14s. per ton.

Medic, G.M.L. 66.—This lease is situated upon the eastern side of the Steere River, about one mile to the northward of Kundip, and upon it a reef has been opened up which strikes at an easterly and westerly direction with an underlay, which varies from 45 to 70 degrees to the southward.

At the west end of the outcrop a small shaft has been sunk upon a vein of stone which was again cut in an underlay shaft 30 feet farther east; this shaft has been sunk to a depth of 85 feet, and at its bottom the reef has been driven on for a distance of 20 feet both east and west. In the eastern of these the stone was of good value, and from it the shoot was stoped up, crossing the underlay shaft and passing away to the westward at a depth of 40 feet from which point it was worked to the surface at the first mentioned shaft. About 30 feet farther east another underlay shaft has been sunk to a depth of 40 feet upon a well-defined formation, but this unfortunately carried no values. At a distance of 80 feet still in the same direction another underlay shaft has been sunk to a depth of 70

feet, which followed down on a small pipe of stone, from which 25 tons of good ore are said to have been raised.

An underlay shaft, 125 feet farther east, has been sunk to a depth of 120 feet, in which the lode in the upper portion dipped at an angle of about 75 degrees, while below this it flattened considerably. From this shaft a body of stone, said to be about 30 feet in length and averaging 2 feet 6 inches in thickness, was stoped from the bottom level up to the surface at a point a little to the westward of the shaft.

Owing to the difficulty in raising water from these inclined shafts, a main vertical one was sunk to a depth of 170 feet at a point about 100 feet farther south. This cut a formation at a depth of 160 feet, which was driven on for a distance of 100 feet east and 40 feet west. This formation has a well-defined hanging wall, but although a considerable quantity of pyrites and a little galena are present in the ore, it so far has only carried low values.

A rise is now being put up at a point 50 feet east of the main shaft with the object of connecting with the old workings where the ore was rich. In the upper workings the country is highly kaolinised, whilst the main vertical shaft was sunk in solid greenstone from the surface.

The water level is at 80 feet in the main shaft, where a heavy supply was at first encountered, but this has now considerably reduced in volume. This supply, which is not very salt, is pumped to the Two Boys battery, about one mile distant.

Table showing the Yield of the Medic Mine.

Year.	Name and Number of Lease.	Ore crushed	Gold therefrom.	Rate per ton.
		tons.	ozs.	ozs.
1904	Medic, G.L. 66	11.00	7.30	0.66
1905	Do. do.	253.00	2 8.63	0.98
1906	Do. do.	113.90	75.41	0.66
1907	Do. do.	242.00	232.02	0.96
To June, 1908	Do. do.	57.56	34.62	0.60
	Total	**677.46**	**597.98**	**0.88**

Harbour View, M.L. 52 (Plate VII.).—This mine which was the first discovered in this locality, and has up to date produced the largest quantity of both copper and gold in the Kundip group, is situated upon a spur of the Ravensthorpe range, upon the eastern side of the Steere river, about one mile in a northerly direction from the township.

The lode is well defined, its outcrop being exposed in a number of shafts and trenches for a length of over 20 chains upon a bearing

of 21 degrees east of north, whilst its underlay varies between 60 and 75 degrees to the westward. It has a well-defined footwall, the country rock upon this side of the lode being a coarse crystalline greenstone schist.

The hanging wall is only exposed at those points where the formation has been crosscut, and at these it presents a more broken character than the footwall, whilst the country is a much finer grained blocky greenstone.

Between the walls, which are often from 12 to 14 feet apart, is a weathered greenstone schist, in which the ore occurs associated with quartz and iron oxide, the richest portions of which, now worked out, were confined for the most part to the footwall.

The ore in the upper levels is carbonate or oxide of copper with a gangue of ferruginous quartz, but at the 160 feet level a small amount of sulphides are making their appearance.

Judging from the size of the stopes, the portion of the lode worked varied from 1 to 6 feet in width, the ore from which was hand picked, and only that of high grade being sent to the smelting works, whilst the balance, which represented about five-sixths of the total, was treated for gold in the battery.

There are three groups of workings upon this mine, viz., the south, central, and northern; the first mentioned being by far the most extensive (see Plate VII.). Taking these in the above order the developments may be described as follows: No. 1 south underlay shaft has been sunk to a depth of 85 feet upon the grade of the lode, and at this depth a level has been driven for a distance of 100 feet in a southerly direction and 90 feet northerly, at which point there is a slight rise in order to connect with the 80 feet level from the main underlay shaft.

From this level, which is called the south drive, a body of ore has been stoped up to a height of 15 to 20 feet, and for a length of 40 feet north of the shaft and 70 feet south, the total length of this which is called the south shoot is 130 feet, and its average width is 6 feet.

This ore is now being stoped below this level and for a depth of 40 feet the same average size is maintained, whilst the trend of the "shoot" is apparently southerly.

The main underlay shaft has been sunk to a depth of 170 feet, with levels at 35, 80, and 160 feet. The 25 feet level has been driven for a distance of 25 feet north, and the 80 feet level 100 feet north and 25 feet south, in which the ore body was 60 feet in length, and had an average width of 4 feet.

This ore body, which is called the north "shoot," has been stoped up from this level to the surface with apparently a southerly trend, but no work has been done upon it below this level.

In the 160ft. level the formation has been driven on for a distance of 30 feet north and 300 feet south, in the latter of which the south "shoot" of ore was cut at a distance of 130 feet from the shaft and here proved to be 120 feet in length with a width of from 3 to

BULLETIN Nº 35 PLATE VII

The Hon. H. Gregory, M.L.A.
Minister for Mines.

PLAN & SECTION OF
THE HARBOUR VIEW
MINERAL LEASE 52
RAVENSTHORPE
PHILLIPS RIVER G.F.

0 80 160 240 320
Scale of Feet.

Stoped

TAKEN FROM MINE PLANS 30 4 07.

A. Gibb Maitland
Government Geologist.

C. B. Kidson del.

H. J. Pether, Government Lithographer, Perth W.A.

4 feet, thus showing a considerable decrease in size from the level above in which it averaged 6 feet.

Although slightly below the permanent water level the sulphides are only just beginning to make their appearance in this drive, whilst in spite of the fact that the copper seems to have been leached from the section of the lode immediately below the surface, so far no signs of secondary sulphides enrichments are apparent.

The central group of workings are situated about midway between the other two; they consist of two shafts, one of which is 60 feet in depth upon the underlay, and from it some ore has been raised.

In the northern workings, which are 110 feet in depth, the lode bifurcates to the southward of the shaft, but whether this is only a spur striking off into the country or will unite after enclosing a horse of country, yet remains to be proved.

Northward of this shaft the lode appears to be again cut off by a cross fault, but since the footwall is so well defined up to it there appears to be no indication of the termination of the fissure, which has more probably been displaced.

In this section of the mine there was so little copper in the stone that it was all sent to the battery for treatment.

Up to the present time 912 tons of ore have been smelted from this mine, averaging 14.36 per cent. of metallic copper and 5,243 tons of stone crushed which yielded .39 ounces of fine gold per ton; this represents about half or a little under of the total gold contents on account of the unsatisfactory battery extraction and the unsuitable character of the ore for cyaniding.

Table showing the Yield of the Harbour View Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1900	Harbour View Leases, M.L. 52 and 94	23.00	1.39	36.00
1901	Do. do. ..	209.20	1.66	18.69
1902	Do. do.	272.75	..	5.63
		1,492.75	0.39	..
1903	Do. do.	6.69	..	9.00
		296.00	0.56	..
1904	Do. do.	43.99	..	20.39
		1,254.50	0.43	..
1905	Do. do.	48.73	..	14.24
		576.0	0.50	..
1905	Ravensthorpe G.M. Syndicate, N.L.	94.89	..	15.92
		701.00	0.52	..
1906	Do. do.	32.79	..	25.67
		423.00	0.15	..
1907	Do. do.	4.88	0.39	17.00
1907	Harbour View Leases	52.74	..	17.00
		500.00	0.18	..
To June, 1908	Do. do. ..	122.17	0.37	15.65
	Total	6,155.08	0.41	2.14

This ore has realised an average value of £3 per ton.

Omaha and *Harbour View North,* G.M.Ls. 73, 81.—These leases, which are situated to the northward of the Harbour View mine, together with the Kundip and the Star of Peace, were included in the original Omaha, M.L. 132, which was worked in 1902 and 1903.

So far no well-defined lode has been discovered upon them, but small veins have been worked upon at no less than six different points.

Table showing the Yield of the Omaha Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1902	Omaha, M.L. 132	241.00	0.34	..
1903	Do. do.	9.15	..	15.00
1905	Omaha, G.L. 73	43.50	3.55	..
1906	Do. do.	50.44	2.11	..
1907	Do. do.	10.00	3.26	..
	Total	354.09	1.04	.00

Table showing the Yield of the Harbour View North Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1906	Harbour View North, G.L. 81	31.00	0.67	..
		1.44	..	19.44
1907	Do. do.	50.00	0.54	..
		1.48	..	1.35
To June, 1908	Do. do.	31.00	0.37	..
	Total	114.92	0.51	0.03

Ore has realised £2 8s. per ton.

Table showing the Yield of the Kundip Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Rate. therefrom.
		tons.	ozs.	ozs.
1906	Kundip, G.L. 78	50.00	20.74	0.41
1907	Kundip, G.L. 133	161.00	43.82	0.27
	Total	211.00	64.56	0.30

Flag Gold and Copper Mining Co., Ltd., G.M.Ls. 136/9 (Plate VIII.).—This mine, which was originally known as the Red, White, and Blue, is situated upon a spur of the Ravensthorpe Range about one mile to the eastward of Kundip Township.

Across leases 136, 137, and 138 upon a course a little south of west are a series of shafts and opencuts which are assumed to have proved the continuity of a line of lode for a distance of 1,100 feet. Owing however to the very great irregularity in its course at the different points at which it has been opened upon, this assumption although quite possible is by no means conclusive, for so far the longest drive is only 230 feet, and even in this the ore body is not continuous.

Upon the other hand the erratic course of the lode may be due to the fact that since this line of fissure crosses the schistose rocks at nearly right angles it would in all probability have been deflected by their planes of foliation.

At the extreme western end of this line of workings a small shaft has been sunk to a vertical depth of 20 feet with a short drive at its bottom to the eastward upon a small vein of ore which measures 2 feet 5 inches in thickness and assays 2.6 per cent. of copper and 13 dwts. of gold.

To the eastward of this shaft the lode, which has a course of 28 degrees south of west, has been worked from an opencut for a length of 65 feet and to a depth of from 10 to 15 feet, its average thickness being about 2 feet 6 inches and value 6 per cent. of copper and 9 dwts. 14 grains of gold. At the east end of this cut another small shaft has been sunk to a vertical depth of 30 feet and the vein which was cut measured 2 feet in thickness and assayed 7 per cent. of copper and 1 oz. 2 dwts. of gold.

One hundred feet farther east is another opencut in which the lode had a course of 21 degrees south of west, averaging 3 feet in thickness for a length of 30 feet and having an assay value of 1.23 per cent. of copper and 9 dwts. 19 grains of gold.

A little south of this a vertical shaft has been sunk to a depth of 30 feet and the lode which is here 5 feet in thickness has been driven upon for a short distance to the eastward, from which 23 tons were sent to the battery and yielded at the rate of 11 dwts. 10 grs. of gold per ton. This ore was of a highly ferruginous character and contained some rich nodules of copper.

At a distance of 100 feet east is an opencut which is the top of a stope from which a body of ore has been worked out, the course of which was 20 degrees north of west for a length of 30 feet. A little east of this a vertical shaft (No. 2) has been sunk to a depth of 100 feet (water level), whilst at a depth of 50 feet the lode has been driven upon for a length of 75 feet and the ore body which was here of considerable size has been stoped up to the surface for a length of 30 feet to the point previously mentioned.

At a depth of 100 feet the lode, which has a course a little north of east and underlays at an angle of 66 degrees to the southward, has been driven upon for a distance of 320 feet, this level connecting with the No. 1 shaft at a distance of 230 feet. At this level at the bottom of No. 2 shaft there was no ore for the first ten feet, after which a large body measuring 9 feet 9 inches in thickness and assaying 8dwts. 8 grains of gold was met with; then, after another blank of 30 feet for a distance of 140 feet, a lode body averaging 3 feet in thickness and assaying 14 dwts. of gold is exposed followed by 40 feet of barren country. After passing the No. 1 shaft some 15 feet, driven in barren country, the main ore body of the mine is encountered and driven through for a length of over 70 feet, in which length its average width was 3 feet. The ore between this level and the surface has been entirely stoped out; that rich in copper was picked out by hand; it is reported to have been worth 8.8 per cent. of copper and 1oz. 17dwts. 19grs. of gold per ton, whilst the bulk of the ore which was treated in the battery assayed 1oz. 16dwts. for gold.

Below this level this ore body has been followed down by a winze to a depth of 45 feet and a portion of it stoped which measured four feet in thickness and the picked smelting ore from which assayed 6.32 per cent. for copper and 2ozs. 2dwts. 16grs. for gold.

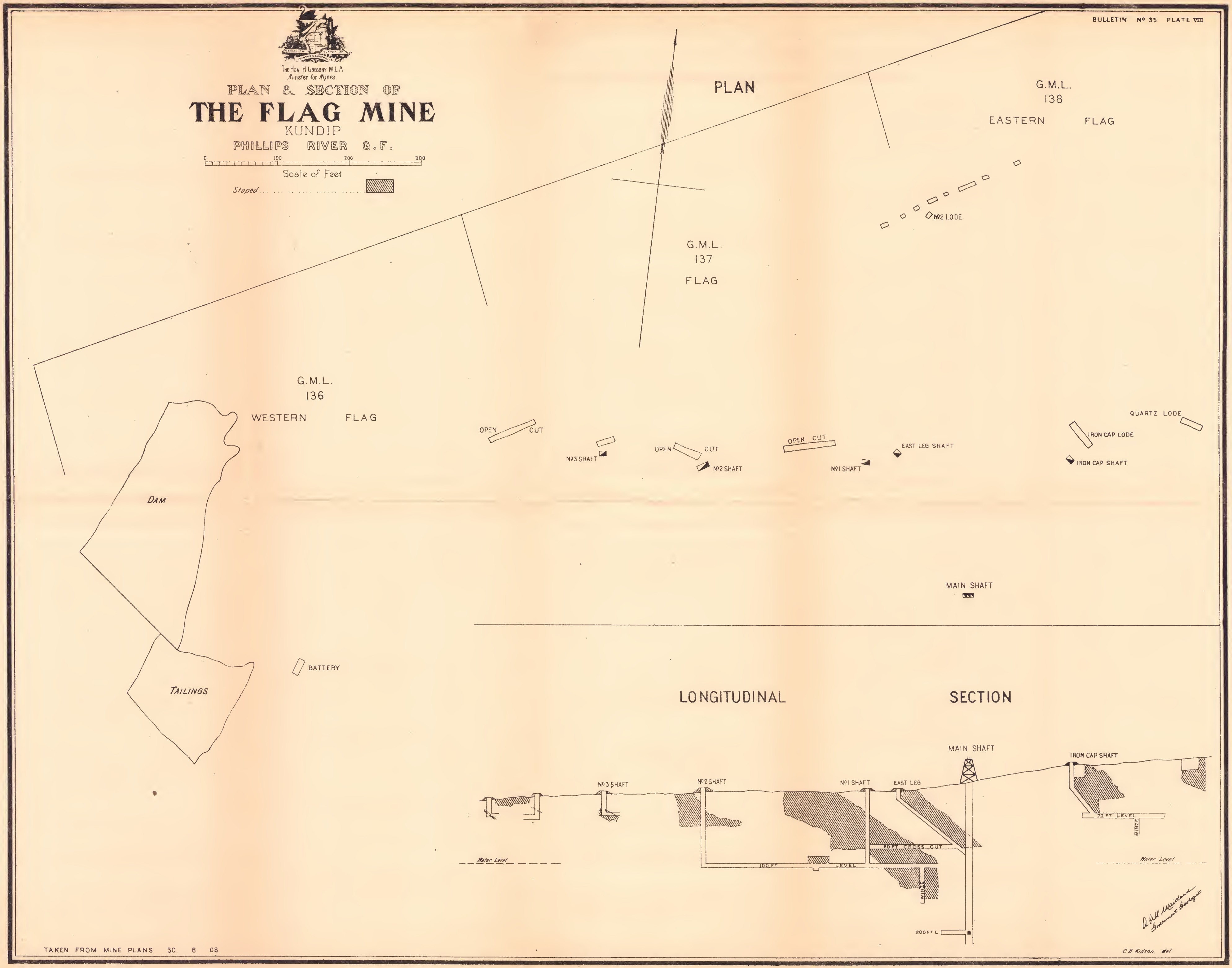
The new main shaft has been sunk at a point 220 feet southeasterly from the No. 1 shaft to a depth of 210 feet from which, at 200 feet, a crosscut has been driven for a distance of 105 feet in a northerly direction to the lode. From this point it was driven upon in a westerly direction for a distance of 40 feet, whilst the vein, which was heavily charged with pyrites in this level, averaged four feet in thickness and assayed 1oz. of gold. In the face, however, the values were improving as a sample taken from there gave a result of 3 per cent. of copper and 2ozs. 1dwt. of gold.

This is supposed to be the downward extension of the main ore body worked in the upper levels, but this cannot be the case, for if it maintains its dip to the eastward, as it appears to do, the continuation will be met with in the level when driven in an easterly direction from the crosscut.

At a point a short distance easterly of the No. 1 shaft an underlay shaft has been sunk upon a small body of ore which follows a course of 40 degrees north of west and dips to the north-east to a depth of 100 feet, the bottom of which is connected with the former by a drive of 110 feet in length at the 80-feet level.

In this vein, which is called the Eastern Leg, a pipe of ore about 20 feet in length and 3ft. 9in. in thickness has been stoped out, the picked ore assaying 11.6 per cent. of copper and 13dwts. of gold.

About 200 feet farther east a ferruginous lode 2 feet in width and assaying 17dwts. 23grs. of gold outcrops upon a course 45



H J Pether, Government Lithographer, Perth, W. A.

degrees north of west with an underlay of 45 degrees to the north-east. This vein was followed down upon the incline to a depth of 70 feet, the upper 20 feet carrying practically no copper values; at this depth however some large bunches of copper ore were met with and the gold values rose. At a depth of 60 feet it developed into a copper lode the ore occurring as a pipe 25 feet in width and from 3 to 6 feet in thickness.

At 70 feet a level has been driven for a distance of 90 feet, 70 feet of which was in lode matter which averaged about 5 feet in thickness and portions of it assayed as high as 18 per cent. of copper and 1oz. 3dwts. of gold.

In this level the lode swings round on to a more east and west course whilst in the winze, which has been sunk 25 feet below it, the dip also turns over to the southward. In this winze the lode is 4 feet in width and assays 7 per cent. of copper and 1oz. 3dwts. of gold.

In driving in a westerly direction at the 70-feet level a large vugh lined with ferruginous gossan was broken into. The roof of this cavity was coated with some fine specimens of malachite, whilst at the bottom there was a considerable quantity of free white sand containing fragments of honeycombed quartz which yielded good prospects of free gold; this latter, however, was of considerably less value than that generally obtained in this mine owing to the presence of a large quantity of silver.

This vugh is not a solitary example in this mine for a similar one of even greater dimensions was met with in driving the 100ft. level in the main workings. They are clearly due to the decomposition of large bunches of pyrites the iron and sulphur from which have been leached out, leaving only the quartz with the gold and silver contents as white sand, whilst the malachite has been precipitated by downward perculation at a later date.

From these workings, 114 tons of ore have been smelted, which yielded 1oz. 2dwts. 14grs. of gold and 10.8 per cent. of copper per ton, whilst 344 tons crushed returned gold at the rate of 14dwts. 7grs. per ton.

About 300 feet farther east is another open cut exposing a large quartz lode having a course 13 degrees north of west, from which a quantity of stone has been crushed which yielded 13dwts. of gold per ton.

At a distance of 300 feet north there is another line of lode following a course of 32 degrees south of west which has been opened by a series of pits and trenches for a length of 200 feet, whilst a vertical shaft has been sunk to a depth of 40 feet at the bottom of which the lode splits into two veins, the footwall one being 10 inches in thickness and assaying 16 per cent. of copper and 13dwts. of gold whilst the hanging wall vein is 12 inches wide and assays 1oz. 17dwts. 18grs. From these workings 6 tons of ore were smelted which yielded 18 per cent. of copper and 1oz. 7dwts.

of gold per ton; and 39 tons were crushed returning 16dwts. 9grs. of gold per ton.

The main lode is highly ferruginous in part, particularly where copper is present, whilst the other more highly siliceous portion carries only gold. The ore is oxidised in all the upper workings but traces of sulphide such as bornite and copper glance occur below the water level in the winze, whilst the ore at the 200-feet level consists principally of sulphide of iron with only traces of copper.

The lode is not well defined, good smooth walls being quite of rare occurrence; whilst the deposition of copper in the lode appears to have been influenced by the character of the rock through which the fissure has cut, the shoot-like enrichments following down the intersection of their foliation planes.

The water level was originally 100 feet below the surface. but since it was drawn at the rate of 60,000 gallons per day whilst working at the 200ft. level, this has been considerably lowered in the upper workings. The water is salt but not extremely so. the quantity contained being only 1.5 per cent.

Taken upon the whole this is more correctly speaking a gold mine which contains copper ore in portions of high enough value to smelt. What its character will be in the sulphide zone will shortly be proved when work is recommended at the 200ft. level.

The great drawback up to the present has been the exceedingly poor extraction by battery treatment which has only been from 40 to 50 per cent., whilst owing to the presence of copper this has been unrecoverable with cyanide of potassium.

Table showing the Yield of the Flag Gold and Copper Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper therefrom.
		tons.	ozs.	%
1901	Red, White and Blue, M.L. 60	10.75	..	24.56
1902	Do.	185.50	.22	
1903	Do.	7.97	..	19.07
1904	Do.	42.34	..	16.10
		508.10	.67	
1905	Do.	171.96	..	11.43
		250.00	1.84	
1906	Do.	62.00	.78	
		216.42	..	8.00
1907	Flag, G.L. 136–9	40.06	..	6.90
		665.00	.66	
To June, 1908	Do.	149.39	1.15	7.42
		359.00	.50	
	Total	2.668.49	.70	2.32

This ore has realised an average value of £4 5s. per ton.

ADDENDA.

The Department is indebted to Mr. Robert Hastie, a former Minister for Mines, for the following table giving the total yield of the Flag Gold and Copper Mine up to date.

A. G. M.,
G. G., 24-6-09.

Summary of the Ore treated from the Flag Mine, showing the gross tonnage, gross contents, and values. Values of Copper taken at market price at time of delivery and Gold at £4 per ounce.

By present Company from inception to May 31st, 1909 :—

	Tonnage.	Tons Copper.	Ozs. Fine Gold.	Gross Value.
				£ s. d.
Sold to Smelter up to 31-12-08	808·3625	75·0	968·844	8,910 14 5
Do. do. 31-3-09	981·5	63·947	832·350	7,079 11 1
	1789·8625	138·947	1801·194	15,990 5 6
			Bullion.	
			oz. dwt. gr.	
Crushed at Company's Battery up to 31-5-09	3511·5		2,421 4 11	7,177 19 2
	5301 3625	**138·947**	**4222·394**	**23,168 4 8**

Previous to March, 1907, the mine was known as the Red, White and Blue. It produced :—

	Tonnage.	Tons Copper.	Ozs. Gold.	Gross Value, estimated at £60 per ton Copper and £4 4s. per oz Gold.
				£ s. d.
Red, White, and Blue ...	1222·5	39·11	880·11	6,043 11 3
Flag	5301·3625	138 947	4222·394	23,168 4 8
Total Production of Mine	**6523·8625**	**173·057**	**5102 504**	**£29,211 15 11**

Charmion G.M.L. 132.—This lease is situated upon the same spur of the range, but farther to the eastward than the Flag mine; it was worked in 1906 as the Persic G.M.L. 85, and the Persic Extended G.M.L. 95.

Quite a number of prospecting shafts have been sunk to shallow depths upon two series of small ferruginous quartz veins in a kaolinised schist, one series which strike north and south apparently occur as short lenses, whilst these which follow a more east and west course can be traced for a considerable distance.

Both of these lines of reef have in places yielded very good prospects at the surface, but they did not as a rule carry these values down. These veins are in the same belt of country as the Gem and Two Boys, the reefs in which did not carry values in their upper portions, the poorness of the stone in the shallow workings is therefore no criterion as to its richness at a depth which can only be determined by sinking.

Up to June, 1908, the total production from this area as shown in the official returns under the Persic, Persic Extended, and Charmion is 47½ tons of stone which yielded 28.81 ounces of fine gold.

Try Again G.M.L. 114.—This lease covers a triangular block of ground between the Flag mine and the Charmion, and upon it a number of shafts have been sunk with the object of cutting the lode worked upon the first named property. So far however only a series of small ferruginous quartz veins have been discovered, from which 9½ tons of stone yielded 7.10 ounces of fine gold.

Hecla (late Mt. Pleasant), M.L. 206.—This mine is situated about one mile west of the Mosaic, and upon it a lode striking north and south with a steep dip to the east but nearly vertical has been worked. An adit was first driven into the hill at the south end of the outcrop, whilst later on a vertical shaft was sunk to a depth of 70 feet in formation all the way down.

This formation, which is from 10 to 15 feet in width, consists of kaolinized rock containing nodules of blue and green carbonate of copper, 28.86 tons of which yielded 3.55 tons of metallic copper valued at £308; this ore carries no gold.

Mosaic, M.L. 291.—This mine is situated about four miles from Kundip upon the eastern side of the Ravensthorpe Range. It is not included in the area geologically mapped.

The lode, which has a course of north-west and south-east with a dip of about 70 degrees to the north-east, was first opened up at its north-west end by a vertical shaft 30 feet in depth, and later by an underlay shaft 75 feet deep about 40 feet farther south-east. This latter shaft was sunk in the ore body, which varied from 3 to 4 feet in width, one foot of which is said to have been solid clean ore. About 50 feet farther south-east another underlay shaft has been sunk to a depth of 110 feet upon the other end of the shoot, and in it the vein presents the same character as in the last mentioned.

The ore as a rule does not continue south beyond this shaft, but at one or two points small veins have been followed for short distances, whilst at a depth of 75 feet it has been entirely cut off by a fault dipping to the south-west.

The ore body is about 80 feet in length, and this appears to have been entirely stoped out up to the surface.

After penetrating the fault plane the lode was lost, but was eventually discovered by crosscutting in a north-easterly direction, where it proved to be small and of low value. It was driven on from this point in a south-easterly direction for a distance of 40 feet, whilst the vein which was small and of low value was underhand stoped throughout the entire length to a depth of 12 feet, the ore being raised to the surface by a vertical shaft which connects with this level.

The country rock is talcose schist with magnesite nodules at the surface, whilst the ore is of interest, as this is the only mine upon this field in which Fahl ore is known to exist.

Table showing the Yield of the Mosaic Mine.

Year.	Name and Number of Lease.	Ore treated.	Gold per ton.	Copper per ton.
		tons.	ozs.	%
1904	Mosaic, M.L. 179	33.72	0.23	13.76
1905	Do. do.	19.76	0.20	8.00
1906	Mosaic, M.L. 237	1.67	0.71	11.40
1907	Mosaic, M.L. 291	10.04	0.35	9.56
To June, 1908	Do. do.	7.06	0.45	9.20
	Total	**72.25**	**0.30**	**11.08**

This ore has realised an average of £7 per ton.

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GOVERNMENT ASSAYS.

Assays, Analyses, and Determinations of any Western Australian Ore or Rock will be made by the Assayer to the Geological Survey, **when not unduly interfering with official work,** subject to the following conditions :—

1. Each sample must weigh at least 6oz., but not more than 2lbs.
2. Each sample must be enclosed in a separate canvas bag or strong paper wrapper, with a slip of paper bearing the name and address of the sender, together with a private mark by which it may be readily identified.
3. The parcel must be forwarded, **prepaid**, to :—

The Government Geologist,
Geological Survey Office,
Perth.

4. A letter must be sent at the same time to the same address, stating for what metals the samples are to be assayed, or containing other instructions, as the case may be.

(N.B.—It is always advisable to keep duplicate samples of those submitted.)

5. Before any assay is made the prescribed fee must be paid to the Mineralogist and Assayer, or sufficient reasons, in accordance with Section 7 below, be furnished for having the samples treated free of cost.

6. The following fees will be charged :—

	£	s.	d.
(a.) Determination of a Rock or Mineral	0	10	6
(b.) Assay for Lead, Iron, or Manganese, each ..	0	10	6
(c.) Assay for Silver, Copper, or Tin, each	0	12	6
(d.) Assay for Gold or Zinc, each	0	15	0
(e.) Dry Assay for Lead, Silver, and Gold	1	1	0
(f.) Assay for Antimony, Bismuth, Chromium, Cobalt, Mercury, or Nickel, each	1	11	6
(g.) Proximate Analysis and Calorific Valuation of Coal	1	11	6
(h.) Complete Chemical Analysis of any Mineral or Ore, according to number and nature of determinations .. .. £2 12s. 6d. to	5	5	0
(i.) Other determinations, according to time spent, up to	2	12	6

A reduction of 20 per cent. on the above amounts will be made in favour of any person submitting, in one parcel, five or more samples for identical treatment.

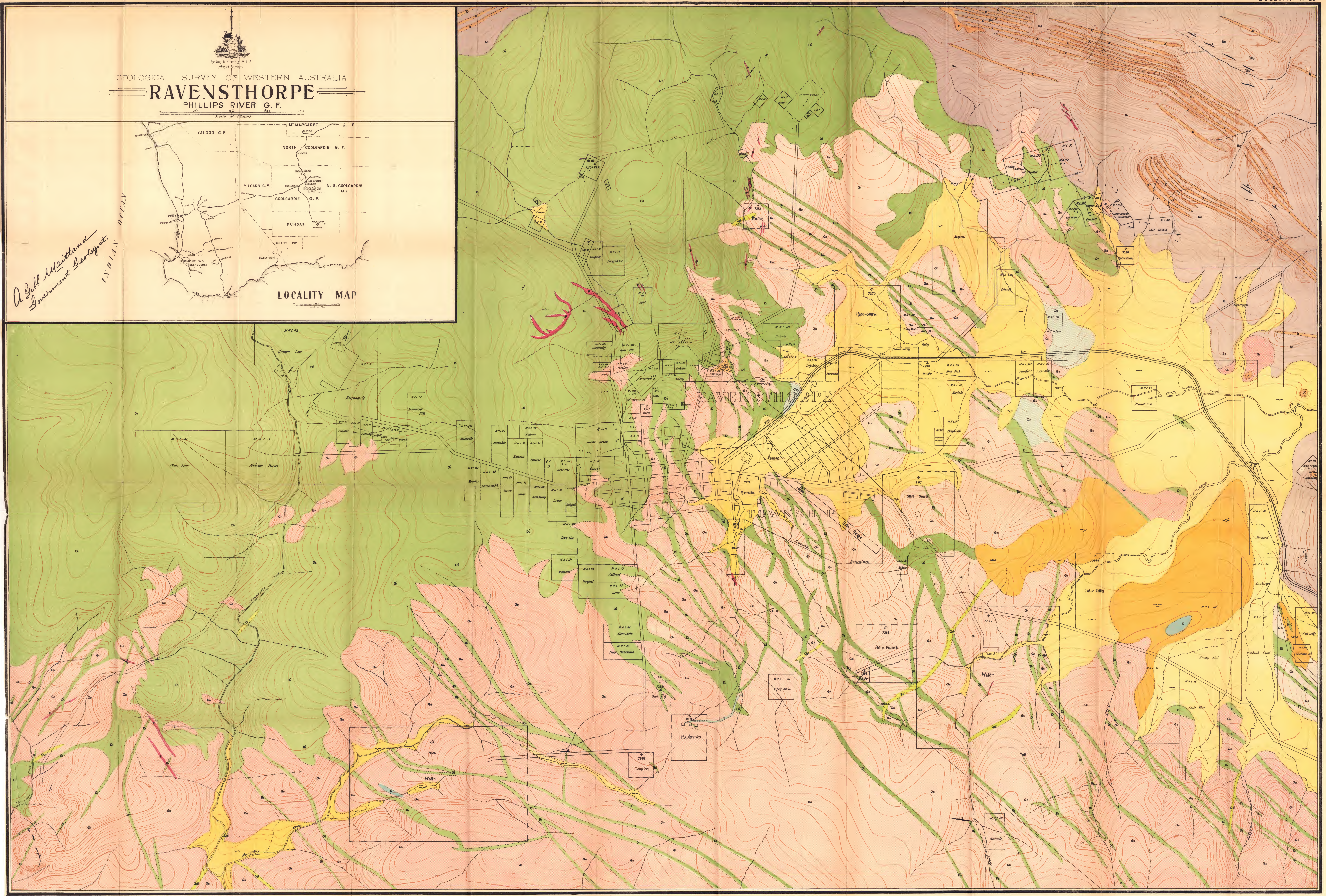
7. With the object of encouraging bona fide prospecting, free Assays will be made under the following circumstances :—

(a.) The sample must have been obtained from land within the State not held under lease for mining purposes.
(b.) The exact locality where the sample was found must be disclosed.
(c.) The sample must be of sufficient promise to warrant an assay being made at the expense of the State.
(d.) Free assays will not be made of samples showing free gold, or of tailings or other metallurgical products, or of umpire samples.

8. The Department reserves to itself the right of refusing to make any particular Assay, and also the right of publishing at any time the results of an Assay made at the public expense.

A. GIBB MAITLAND,
Government Geologist.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.



GEOLOGY BY H. P. WOODWARD ASSISTANT GOVERNMENT GEOLOGIST AND H. W. B. TALBOT FIELD ASSISTANT.

DRAWN BY R. H. IRWIN. December 1908

H. J. Pether, Government Lithographer, Perth W. A.

EXPLANATION OF COLOURS AND SIGNS

ALLUVIUM	~	LATERITE	X	SANDSTONE	K	QUARTZ DIORITE	Qdi
SUPERFICIAL	≈	TRAVERTINE	Ca	GREENSTONES	Di	BASIC SCHISTS	Sc
ACIDIC SCHISTS	Gs	FELSITE & PEGMATITE DYKES	F P				
GRANITE	Gn	QUARTZ REEFS	Q				

Contour lines at 10ft intervals

GEOLOGICAL BOUNDARIES

SHAFTS

WATER RIGHT .... W.R.

MACHINE AREA .... M.A.

BUSINESS " .... B.A.

GARDEN " .... G.A.

LEASES: GOLD .... G.L.; MINERAL .... M.L.; MINERS HOMESTEAD .... M.H.L.

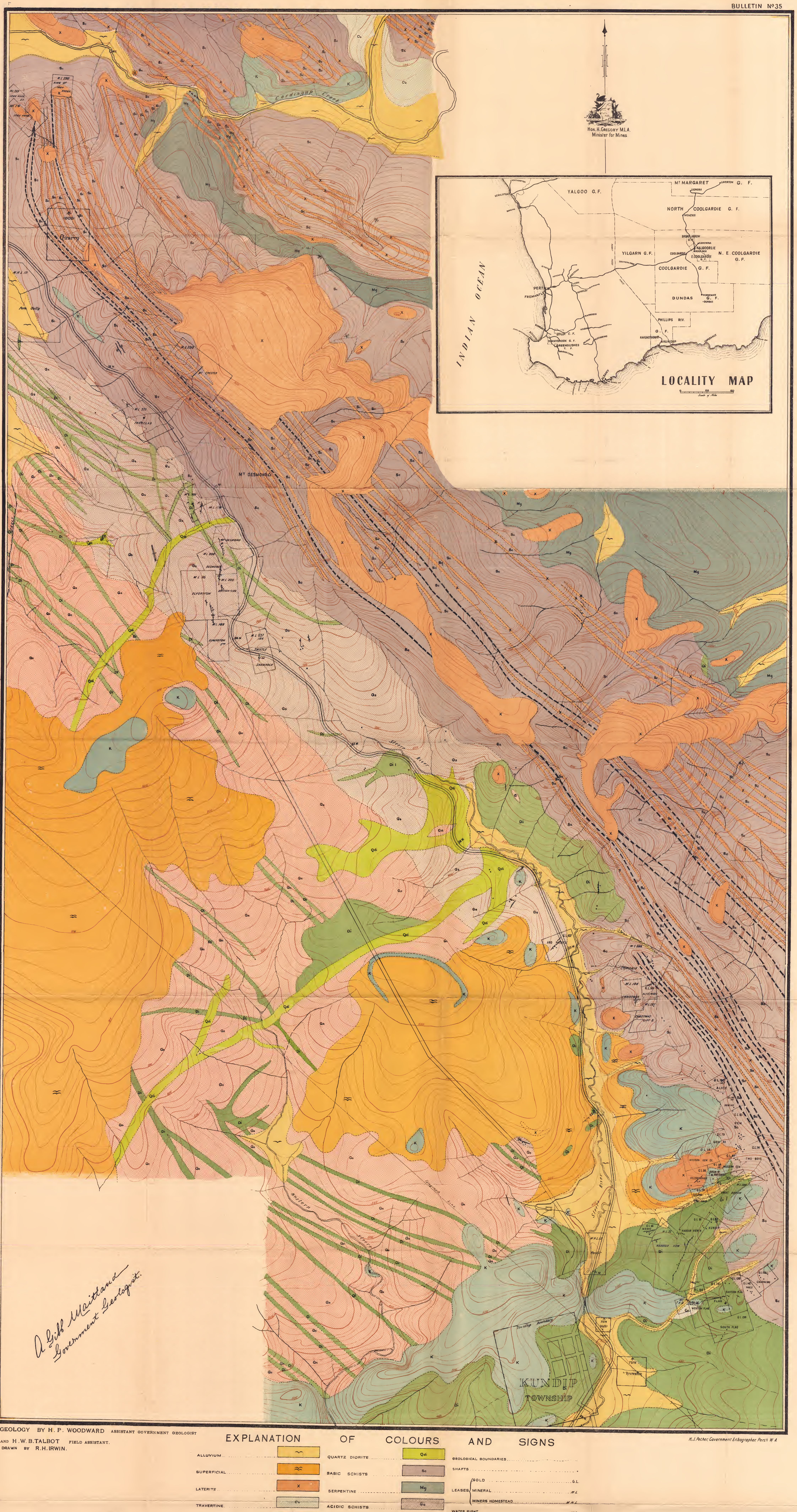
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

DESMOND & KUNDIP

PHILLIPS RIVER G. F.

0 20 40 60 80
Scale of Chains

BULLETIN Nº35



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AND H. W. B. TALBOT FIELD ASSISTANT.
DRAWN BY R. H. IRWIN.

H. J. Pether, Government Lithographer, Perth W. A.

EXPLANATION OF COLOURS AND SIGNS

ALLUVIUM	~	QUARTZ DIORITE	Qdi	GEOLOGICAL BOUNDARIES	
SUPERFICIAL	≈	BASIC SCHISTS	Sc	SHAFTS	
LATERITE	X	SERPENTINE	Mg	LEASES GOLD	G.L.
TRAVERTINE	Ca	ACIDIC SCHISTS	Gs	LEASES MINERAL	M.L.
SANDSTONE	K	GRANITE	Gn	LEASES MINERS HOMESTEAD	M.H.L.
GREENSTONES	Di	BANDED QUARTZITES		WATER RIGHT	W.R.
		QUARTZ REEFS	q	MACHINE AREA	M.A.
		Contour lines at 10ft intervals	710' 700	BUSINESS "	B.A.
				GARDEN "	G.A.

1910.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 36.

III.

Palæontological Contributions

TO

The Geology of Western Australia.

BY

Dr. GEORGE J. HINDE, F.R.S.,

E. A. NEWELL ARBER, M.A., F.L.S., F.G.S.,
University Demonstrator in Palæobotany, Cambridge,

R. ETHERIDGE, Esq., The Curator of The Australian Museum, Sydney, N.S.W.

AND

LUDWIG GLAUERT, F.G.S., Field Geologist.

Issued under the Authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

WITH 12 PLATES AND 5 FIGURES.

PERTH:
BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

1910.

TABLE OF CONTENTS.

PREFATORY NOTE.

The eight contributions to which the Geological Survey is indebted to the authors have been received since the publication of the last palæontological Bulletin, No. 27, in the year 1907.

The first contribution, from the pen of Dr. Geo. J. Hinde, F.R.S., throws considerable light on the conditions prevailing in the Norseman District.

The second, by Mr. Newell Arber, M.A., F.G.S., is an important addition to our knowledge of the Jurassic Flora of Western Australia ; whilst that of Mr. Etheridge, the Curator of the Australian Museum, to whom the Survey is under a debt of gratitude, which it is difficult to repay, adds considerably to our knowledge of the organic remains of the Oolitic Beds of the Greenough River.

The description of *Sthenurus Occidentalis*, from the Mammoth Cave on the Margaret River, was prepared by Mr. L. Glauert, F.G.S., Field Geologist, for the information of the Caves Board.

The list of Western Australian Fossils, stratigraphically and zoologically arranged, which Mr. Glauert has drawn up to facilitate the work of the Geological Survey, will meet a much felt want at the hands of all workers in, and students of, Australian Geology.

The account of the New Fossils from the Barker Gorge, Napier Range, in the Kimberley Division, seems to point conclusively to the occurrence of undoubted Devonian Beds in this portion of the State.

The Notes on the Geological Age and Organic Remains of the Gingin Chalk contain evidence which points strongly to its being Cretaceous and not Tertiary, to which horizon it had previously been assigned.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office,
Perth, 21st March, 1910.

1.—*On the Fossil Sponge Spicules in a Rock from the Deep Lead (?) at Princess Royal Township, Norseman District, Western Australia.*

BY

Dr. GEORGE J. HINDE, F.R.S.

Some months since Mr. A. Gibb Maitland, F.G.S., Government Geologist of Western Australia, forwarded to me for examination a sample of an earthy siliceous rock [**8131**] from the Deep Lead (?), known as the "Princess Royal," situated on the townsite of the same name at the eastern margin of Lake Cowan. Brief references to this deep lead (?) are given in Bulletin No. 21 (1906), of the Geological Survey of Western Australia, where it is stated that it was discovered in February, 1901, in carrying out alluvial workings for gold, mostly in the main street. The depth was 88ft. in kaolin.

Above the "wash" there is a white pug showing the usual slickensides and crush faces and above this ironstone gravel patches. The wash itself is mullocky, with concretions of a magnesian nature, and with quartz particles, etc. This wash is said to have been 30 to 40 feet wide, and about 6ft. in thickness on the west side, and below it there is a gritty brown material, evidently decomposed hornblendic rock.

At the Princess Royal townsite there is a strip of kaolinized ground about a mile long and a quarter of a mile wide, which may be either a remnant of a wider covering or be due to the felsite dykes in this locality being very susceptible to decomposition. At the south end of this patch the deep lead was found. No particular age can be assigned to this kaolin; it is probably mostly decomposed rock *in situ* and has been increasing in depth as long as this has been dry land (pp. 20, 36).

The reports from the Bulletin quoted above respecting the character of the deposits in this deep lead (?) do not make mention of any rock at all comparable with the sample which has been sent to me, and it may be hoped that further investigation will furnish some detailed information as to the thickness of the deposit from which the sample was taken, its position in the series exposed in the lead, and the character of the beds above and below it.

General Characteristics of the Rock.

The sample of rock examined consists of three small irregular lumps of a very light, whitish, finely granular, and powdery material, which is so incoherent, tender, and friable that it readily breaks up into dusty powder between the fingers, and when treated in water with a soft brush it passes into a greyish mud. It may be said to be an aggregation of fine particles without any cementing material to bind them together. There is no indication of bedding to be seen in the lumps. Treated with dilute hydrochloric acid, the rock shows no reaction whatever.

When the powdered rock is examined dry with a strong lens or by reflected light under a microscope, it is seen to be composed mainly of minute glassy rods and granules, and occasionally of entire sponge spicules. It addition to these remains of organic origin there are some minute grains of a dark mineral, and also more numerous clear granules, mostly of quartz. The larger part of the latter are angular or sub-angular, some are rounded, and others seem to be small crystals. †

The spicules of siliceous sponges are the only fossils recognised so far, in the rock sample, no remains of other siliceous organisms, usually associated in marine deposits of this character, such as radiolaria and diatoms, have been met with.

Condition of preservation of the Sponge Spicules.

The chemical constitution of the spicules of which this rock is mainly composed is closely similar to that of recent siliceous sponges. The silica is in the colloid condition and presents the same clear glassy aspect so characteristic of recent spicules and, as in these latter, it is negative in polarized light between crossed Nicols.

Exceptionally some of the spicules are of a milky tint with a porcellaneous appearance, similar to spicules in the Lower and Upper Greensand of the South of England (1) and in the Cretaceous Sponge-beds of Westphalia, and in a few cases also the spicular walls are traversed in all directions by very minute curved lines as in fossil spicules from Wiltshire (2). But the change from the normal glassy condition does not seem to have reached any further stage, and in no instance have I seen a spicule of chalcedonic silica in the material.

† "In my report on the Norseman material I mentioned that some of the quartz grains probably were partially formed in the rock, but I have since had an opportunity of showing these grains to Dr. J. S. Flett of the Geological Survey of Great Britain, and he considers that they have not been enlarged by a secondary deposition of silica, and that they have rather the appearance of having been derived from vein quartz. He further thinks that some of the fine portions of the rock in which the sponge spicules are embedded may be kaolin." G. J. H., 10th September, 1909.

(1.) Hinde. Sponge Remains in the Lower and Upper Greensand of the South of England. Phil. Trans. Roy. Soc., Vol. CLXXV. (1885), p. 426.

(2.) Ibid pl. XL., fig. 8.

The axial canals in these fossil spicules are considerably enlarged, and they contrast strongly with the very fine, oftentimes scarcely visible, axial canals in the spicules of recent sponges. In some instances the silica of the interior of the spicules has been dissolved away to such an extent that only a thin outer sheath of the original wall remains. The enlarged canals have usually smooth and even walls, but not infrequently they are eroded irregularly and have a nodose appearance. The outer surface of the spicules is very commonly covered with small circular pittings and their walls are bored at right angles with neat cylindrical holes which often penetrate to the axial canal of the spicule. Similar borings and enlarged canals are found in detached sponge spicules dredged up from considerable depths and they have been attributed to the action of boring algæ (1).

Comparatively few of the larger spicules in this soft rock are preserved intact ; a large proportion are broken up into small fragments. The larger and more robust monaxon spicules, together with the trifids and calthrops have suffered most from fracture, and uninjured specimens are difficult to find, whilst many of the smaller fusiform, cylindrical, pinshaped, and styliform spicules and the delicate dermal spicules of lithistid sponges, remain in a perfect condition. The skeletal spicules of lithistids have, as a rule, lost their distal ends, by which they are interlocked together. The robust meshwork of dictyonine hexactinellids, which might have been supposed strong enough to resist fracture, is in the material, now reduced to microscopic fragments.

On the whole the preservation of the sponge spicules in this Norseman material is very similar to that of other fossil sponge deposits of Tertiary Age, and it does not markedly differ from that of the detached spicules found at the present time of the sea floor.

DESCRIPTION OF THE SPONGE SPICULES.

With the view of correlating the spicules in this Norseman material with those in similar fossil deposits in other regions, and also with those of recent siliceous sponges, the various forms commingled together in the rock sample are described and figured below. The similar forms of Monaxonid spicules are first considered and afterwards those of Tetractinellid, Lithistid and Hexactinellid Sponges.

Monaxonid Spicules.

The fusiform acerate, cylindrical, styliform, dumb-bell or tibiella and pin-shaped spicules with a single axis are very numerous. With the exception that a few of the larger acerate spicules belong to the Tetractinellida, the rest are the skeleton spicules of the Monaxonida. The very minute so-called flesh spicules are poorly

(1.) Duncan. Journ. Roy. Micros. Soc., ser. 2, Vol. I. (1881), p. 557, pls. VII., VIII.

represented in the deposit by a few forms of chessman or sceptrella spicules belonging to the genus *Latrunculia*.

No anchorate flesh spicules have been observed in the deposit.

Acerate Skeleton Spicules of various genera.

Pl. I., fig. 1.—Fusiform acerate, robust, smooth, slightly curved, greatest thickness in the centre ; tapering gradually to each end. Length 1·5 mm., thickness (1) 0·07. Probably belongs to a species of *Geodia*.

Pl. I., fig. 2.—Fusiform acerate with tapering drawn out ends, smooth. Length 0·43 by 0·05. Common. An axial canal is not shown in these spicules. A spicule very similar in form and proportions occurs in *Desmacidon* (*Homœodictya*) *grandis*, from Simon's Bay, Cape of Good Hope. Ridley and Dendy (Chall. Rep., vol. 20, p. iii, pl. XXIX., fig. 7).

Pl. I., fig. 3.—Fusiform acerate, slightly curved, gradually tapering to both ends which are acutely pointed. It is very similar to the spicules of a variety of *Petrosia variabilis*, Ridley. (Chall. Rep., vol. XX., p. 13, pl. II., fig 12). Length 0·43 by 0·03.

Pl. I., fig. 4.—Fusiform acerate, very evenly curved, the ends blunted, smooth. An axial canal is not recognizable in the specimen figured. Length 0·38 by 0·03. Common.

Pl. I., fig. 5.—Robust fusiform acerate, bent near the centre, tapering towards the ends, which are slightly blunted, smooth. Length 0·33 by 0·035.

Pl. I., fig. 6.—Robust vermiculate spicule, curved and undulating ; surface smooth. The axial canal opens at both ends, which are blunted. Length 0·68, thickness 0·064. Rare.

Pl. I., fig. 7.—Acerate, straight or slightly curved, tapering near the ends, which are blunted; the surface is covered with minute conical spines. Length 0·22 by 0·03. Smaller but similarly spined spicules are present in the sponge deposits at Oamaru, New Zealand (Linn. Soc. Jour. Zool., vol. XXIV., p. 184, pl. VII., fig. 15), and in the recent *Halichondria infrequens*. Carter, from the Gulf of Manaar (Ann. and Mag. Nat. His. s. 5, vol. VII., 1881. p. 369, pl. XVIII., fig. 9*a*.)

Cylindrical Spicules of various genera.

Pl. I., figs. 8, 9.—Slightly curved cylindrical spicules, smooth, with ends evenly rounded. As a rule no axial canals are shown in these forms; they vary greatly in size, the larger range to 0·46 by 0·06, the smaller are nearly reniform and about 0·08 by 0·03. The specimens are numerous and well preserved. Similar spicules are present in the Oamaru deposit (*op. cit.*, p. 184, pl. VII., figs. 31, 36), and also in the material dredged by the "Egeria" from a depth

(1.) The dimensions of the spicules are in all cases given in millimeters and decimal parts thereof, it is proposed therefore to omit "mm." after each measurement.

of 3,001 fathoms off the South-West coast of Australia. *Strongylophora durissima*, Dendy, from the Gulf of Manaar, is built up of similar spicules of various sizes. (Supp. Rep. Pearl Oyster Fisheries, Gulf of Manaar, p. 141, pl. IX., fig. 1.)

Pl. I., fig. 10.—Curved cylindrical spicule, with evenly rounded non-inflated ends, the surface with slightly raised whorls or rings with the edges minutely spined. Length 0·29 by 0·025. Smaller spicules similarly spined occur in the Oamaru material (op. cit., pl. VII., figs. 29, 30), and Mr. Carter has figured a detached spicule of the same kind from the Gulf of Manaar (Ann. and Mag. N.H., ser. 5, vol. VI., 1880, pl. V., fig. 29). The sponge to which these belong is unknown.

Pl. I., fig. 11.—Robust, straight, cylindrical, spicule with round, spined ends, the lateral surface with stout blunt spines disposed in whorls. Length 0·25 by 0·085. Approximately similar spicules, but with the spines not so regularly arranged, are present in the Oamaru material (*op. cit.*, p. 187, pl. VII., figs. 42, 43).

Pl. I., fig. 12.—Subcylindrical spicule with a prominent acute spine at each end, and the lateral surfaces armed with whorls of alternate larger and smaller spines. Length 0·2 by 0·09 in width, spines included. Similar spicules are present in material dredged by the "Egeria," lat. 36° 53′ S., long. 115° 48′ E., depth 3,001 fathoms. Sponge unknown.

Pl. I., fig. 13.—Subcylindrical, slightly curved, with a prominent spine at each end, lateral surface with whorls of subequal spines. Length 0·28 by 0·08.

Tibiella or Dumb-bell Spicules.

Pl. I., fig. 14.—Slightly curved tibiella, shaft fusiform with sub-spherical ends, smooth. Length 0·17 by 0·015.

Pl. I., fig. 15.—Tibiella nearly straight, the shaft cylindrical with a round knob at each end, smooth. Length 0·37, thickness of shaft 0·02, of terminals 0·03. Similar but somewhat smaller spicules are described by Carter in *Forcepia crassanchorata* from Port Elliot, South Australia (Ann. & Mag. N.H., s. 5, vol. XV., 1885, p. 111, pl. IV., fig. 3*b*).

Pl. I., fig. 16.—Tibiella, slender, curved, shaft cylindrical with spherical ends, smooth. Length 0·1 by 0·005, terminals 0·007. Rare.

Sceptrella or Chessman Flesh Spicules of LATRUNCULIA, Bocage.

Pl. I., fig. 17.—Sceptrella with a relatively stout axis, the base expanded with small divergent spines, a median disc armed with short spines and a cupolar summit, also spined. Height, 0·07, thickness of shaft 0·017, width of median disc 0·05. Rare.

Pl. I., fig. 18.—Sceptrella small, with stout axis, base expanded with a thin spined edge supported on a fringe of acute spines

extending obliquely downwards ; a thin median disc with sharp edge ; the summit convex, smooth, with a sharp margin. Height 0·055, breadth of base and summit 0·045.

Pl. I., fig. 19.—Sceptrella with a slightly expanded and arched base with downward projecting spines ; in the middle of the shaft a whorl of horizontal spines ; the summit with a marginal fringe of spines and a prominent vertical spine. Height 0·066, width of axis 0·066 ; of the central whorl 0·026. Rare.

Pl. I., fig. 20.—Sceptrella with a stout axis and an arched and spined base, a medium sharp edged disc ; the summit convex with vertical spines. Height 0·063, width of shaft 0·02, of the median disc and summit 0·036. Rare.

Pl. I., fig. 21.—Sceptrella relatively small, the basal portion and median disc similar to the preceding in form, the summit like truncated cone with minute spines. Height 0·04, width of shaft 0·011, of median disc 0·026. Rare.

Pl. I., fig. 22.—Sceptrella with slender cylindrical shaft and a small median disc with smooth margin, the summit slightly expanded with the margin notched. Length 0·05, width of shaft 0·006, of median disc 0·02.

Four of the forms of Sceptrella described above (pl. I., figs. 17, 18, 20, 21) are modifications of a common type which has an expanded base with divergent spines, a median disc and a convex summit : in fig. 19 there is a median whorl of spines and at the summit a prominent spike, whilst in fig. 22, there is no distinctive base, a small median disc and a notched summit. Each of these forms may represent a distinct species of *Latrunculia*. Similar variations of form-details are shown in the Sceptrella spicules of the Oamaru deposit (op. cit. p. 215, pl. XI., figs. 15–39).

Style or Acuate Spicules.

Pl. I., fig. 23.—Part of an elongated tapering spicule, probably a style similar to those in the genus *Tethya*, Lam. The part preserved is 1·64 in length by 0·04 in thickness at the fractured end.

Pl. I., fig. 24.—Style, robust, smooth, slightly curved at the proximal end, and tapering in the lower third of the spicule. Length 0·72 by 0·04. Similar skeleton spicules are present in the recent *Myxilla hastata*, Ridley and Dendy, from off the mouth of the Rio de la Plata at 600 fathoms. (Chall. Rep. vol. 20, p. 134, pl. XXVII., fig. 1). Common.

Pl. I., fig. 25.—Style slender, slightly curved, nearly of an even thickness throughout. Imperfect at the distal end. Length 0·73 by 0·02. Rare.

Pl. I., fig. 26.—Style slender, elongate, smooth, the summit evenly rounded and curved nearly at right angles to the straight,

gradually tapering shaft. Length 0·37 by 0·017. A similar but somewhat more robust spicule occurs in the Oamaru material (*op. cit.*, p. 191, pl. VIII., fig. 30).

Pl. I., fig. 29.—Nearly straight, robust style, the upper third stout, then somewhat rapidly tapering to the apex. The upper portion of the spicule is covered with minute conical spines, the lower two-thirds is quite smooth. Length 0·39, maximum thickness 0·06. Rare.

Spinulate or Pin-shaped Spicules.

Pl. I., fig. 27.—Robust spinulate slightly curved, head spherical, constricted at the neck, shaft slightly increasing in thickness towards the middle, the lower portion of the spicule is wanting. Length (incomplete) 0·57 by 0·05.

Pl. I., fig. 28.—Straight, smooth spinulate, head spherical, neck slightly constricted, very gradually tapering to the apex. Axial canal normal. Length 0·42 by 0·02. A similar spicule is present in the Oamaru material (*op. cit.*, p. 193, pl. IX., fig. 6).

Spines of Tetractinellid Sponges.

Calthrops Spicules.

Pl. I., fig. 30.—Robust calthrops, the rays sub-equal, smooth, gradually tapering. Length 0·28 by 0·06.

Calthrops spicules of various sizes are fairly common in the Norseman deposit, some are larger, others smaller than the specimen figured. They have in all cases, smooth, simple rays. Similar spicules are present in the Oamaru deposit (*op. cit.*, p. 231, pl. XIII., figs. 35–40) and in fossil sponge deposits generally.

Trifid Spicules of Geodia and other genera.

Pl. I., fig. 31.—Trifid with straight tapering shaft and simple head rays directed obliquely forwards. Length of shaft (incomplete) 0·34 by 0·05 ; head rays 0·16 by 0·04. It may be compared with the smaller trifid spicules of the Oamaru material (*op. cit.*, p. 234, pl. XIII., figs. 14, 15).

Pl. I., fig. 32.—Trifid with simple slightly curved and nearly horizontal head rays. The shaft is broken away just below the head, it is 0·035 in thickness : the rays are 0·08 in length. This spicule corresponds in form and size with the zone spicules of the recent *Stelletta reticulata*, Carter, from off the South coast of Australia (Ann. & Mag. N.H., ser. 5, vol. XI., 1883, p. 352, pl. XIV., fig. 46).

Pl. I., fig. 32.—Trifid, with simple, strongly curved head rays. Shaft (imperfect) 0·03 in thickness, head rays about 0·1 in length. It probably belongs to a species of *Geodia*. Similar spicules are found in the Oamaru material (*op. cit.*, p. 235, pl. XII., fig. 24),

and in deposit brought up by the "Egeria" off S.W. of Australia, lat. 36°·08′ S., long. 117°·10′ E., from a depth of 2,479 fathoms.

Pl. II., fig. 1.—Spicule with a tapering shaft and a single, slightly recurved head ray ; the base of a second ray is shown, but there is no indication of a third. The shaft is 0·23 by 0·02, the head ray 0·037 in length. It appears to be an abnormal development of a trifid spicule.

Pl. II., fig. 2.—Trifid with straight elongate shaft and with each of the head rays bifurcated and horizontally extended. The tips of the rays are broken away, and the axial canal in the shaft is considerably enlarged. Shaft 0·36 by 0·03 : width across the head rays 0·13. Similar spicules are present in the genus *Erylus.* Gray.

Pl. II., fig. 3.—Trifid with simple head rays directed upwards. The shaft (imperfect) is 0·04 in thickness, the head rays 0·12 by 0·02. Similar spicules occur in the recent genus *Craniella*, O. Schmidt and in *Stelletta* they are also present detached in the Oamaru material (op. cit. p. 234, pl. XIII., figs. 16, 17).

Pl. II., fig. 4.—Trifid spicule with a stout, straight shaft, and bifurcated head rays. The shaft is 0·05 in length. It may belong to *Erylus.* Gray. A form nearly similar is figured from Oamaru (op. cit. p. 234, pl. XIII., fig. 12).

Pl. II., fig. 5.—Trifid with curved tapering shaft and trifurcate head rays directed obliquely forwards. The head rays are partly broken, but in one the trifurcate character is distinctly shown by the axial canals. Shaft 0·37 by 0·05. The head rays are 0·14 in length.

Pl. II., fig. 6.—Trifid with slender shaft and simple head rays directed backwards. The shaft is 0·006 in thickness, the head rays are 0·05 in length and about the same thickness as the shaft. It may be compared with the grapnel spicules of *Cydonium Mülleri*, Fleming—*Geodia Zetlandica*, Johnston (*see* Bowerbank, Mon. Brit. Spong. vol. III., pl. VII., fig. 7). Similar forms are common in the Oamaru material (*op. cit.*, p. 235. pl. XII., figs. 18–24).

Lithistid Spicules.

Body Spicules of Ragadinia, Zittel, *and* Discodermia, Bocage.

Pl. II., figs. 7, 8.—Spicules with four arms or rays ; one is frequently truncated or reduced to a rounded knob ; the fully developed arms have a prominent ring-like inflation a short distance from the spicular centre ; beyond the ring the arms bifurcate and terminate in twig-like extensions which interlock with those of adjoining spicules. The delicate twig-like extremities are broken off the detached spicules. In one specimen (fig. 7), the axial canal is seen as a delicate straight line extending from the centre to about two-thirds the length of each arm ; in the other (fig. 8), the canals are widened and reach to the ends of the arms, which are, however,

incomplete. The arms are about 0·17 in length, and 0·04 thick near the centre. The spicules belong to *Ragadinia*, Zitt. of which several species are known from the upper Cretaceous (*Bel. mucronata* Zone) of Germany and the South-West of England. Detached spicules closely resembling those from Norseman are known from Coesfeld in Westphalia, the Upper Chalk of Norfolk (1): also in the Upper Greensand near Warminster, Wiltshire, and in the Lower Greensand of Haslemere and Tilburstow Hill, Surrey (2).

Pl. II., figs. 9, 10.—Both the spicules figured are imperfect: in one (figure 9) an arm is wanting, and in the other (fig. 10) two are broken away, so that their original tetractadine character can hardly be recognised. Small extensions are given off from the arms; their ends are frequently furcate and they are covered with tubercles. In one (fig. 9), a delicate straight line in the principal arm may represent an axial canal whilst in the other (fig. 10), two short canals are shown near the broken margin. These spicules may belong to *Discodermia*, Bocage. Fragments of similar spicules are very common in the Norseman material.

Reniform and Globostellate Spicules of Tetractinellid Sponges.

Pl. II., figs. 12, 13.—Reniform spicules, similar to those forming the dermal crust of *Geodia* sponges, are very numerous in the deposit. Generally the hilum can be distinguished, but the minute rods with prominent heads of recent forms are not shown in these fossil specimens. Not infrequently they are perforated by boring algæ (?) as in the specimen figured (fig. 13). Small specimens measure 0·07 by 0·037, the larger 0·09 by 0·062.

Pl. II., fig. 14.—Globostellate spicules, apparently solid, their surfaces covered with short, stout, conical spines, which in some cases seem to be regularly disposed in lines. Diameter 0·1. Fairly numerous.

Pl. II., fig. 15.—Globostellate similar to the preceding, but much smaller. Diameter 0·04—0·05. Very common. Similar forms are present in the recent genus *Cydonium*, Muller.

Pl. II., figs. 16, 17.—Globostellate spicules with solid centra from which extend a number of stout cylindrical rays with expanded lobate summits. No canals are visible either in the rays or in the centra. Diameter 0·1. Similar spicules are present in the recent *Cydonium Mülleri* Fleming. They occur detached at Oamaru (op. cit. p. 237, pl. XIV., figs. 28, 29, 30, and also in the dredgings by the "Egeria" off the S.W. of Australia, from a depth of 2·479 fathoms.

Globostellate Spicules of TETHYA, Lamarck.

Pl. II., fig. 18.—Globostellate with numerous rays which originate in the centre of the spicule and for about one-third their length

(1.) Hinde. Fossil Sponge Spicules from the Upper Chalk of Horstead, 1880, p. 58, pl. 5, figs. 1–4.

(2.) Phil. Trans. Roy. Soc., vol. CLXXV., part II., 1885, p. 444, pl. XLV., figs. 5, 5a, 5b.

extend beyond the centrum. The rays are straight and the free portions gradually taper. In each there is a well-marked, now enlarged, canal, which begins at the origin of the ray and opens at its free distal end. The figured specimen is 0·13 in diameter: smaller forms are about 0·08, including the rays. These spicules are closely related to those of *Tethya robusta*, Bowerbank (Proc. Zool. Soc. Lond., 1873, p. 10. pl. II., fig. 15) now living in Australian seas. They are very common in the Norseman material, but as a rule the free portions of the rays are broken off. Similar detached forms are present in the Upper Cretaceous (Zone of *Bel. mucronata*) of Westphalia, and in the same zone of the Chalk of Norfolk.

Pl. II., fig. 19.—Small globostellate with 12–14 acutely pointed rays extending for about half their length beyond the centrum. No canals visible. Diameter, including rays, 0·05. This form may be one of the smaller stellates of the crust of a species of *Tethya*.

Dermal Spicules of Lithistid Sponges.

Pl. II., figs. 20, 21.—Spicules consisting of a thin, flattened siliceous plate with very irregular lobate margins. In the centre of the plate is a short, acutely pointed shaft which projects at right angles from the inner or lower surface. Three short canals radiate from the junction of the shaft with the plate and in the central point is a small circle representing the axial canal of the shaft. The shaft in these spicules is usually broken off the horizontal plate. The plate or head of these spicules is about 0·3 in breadth. The sponge to which they belonged cannot be known with certainty; they may have formed the dermal layer of a species of *Ragadinia* whose skeleton spicules have been described above.

Dermal Spicules of Discodermia, Bocage.

Pl. II., fig. 22.—The spicule figured has the margins rounded, but in other specimens of the same form they are irregularly lobate. The outer surface has numerous minute spines or papillæ, as Carter terms them, and these are connected with each other by delicate raised lines which give the appearance under the microscope of a fine network with polygonal meshes. Three short axial canals are shown in the centre of the spicule. The spicular heads are 0·3–0·38 in breadth. The shafts are wanting. The late Mr. Carter has described dermal spicules with a similar surface network in the recent *Discodermia aspera* from the Gulf of Manaar (Ann. & Mag. N.H., ser. 5, vol. VI., 1880, p. 501, pl. VIII., fig. 49*g*), but in a microscopic slide of the spicules of this sponge, mounted by himself and presented to me, there is no net-work shown on the dermal spicules, nor does Prof. Sollas mention this character in describing *D. aspera* though he studied the spicules in a slide also supplied to him by Mr. Carter (Chall. Rep. vol. XXV., p. 327). It is probable therefore that the dermal spicules with this peculiar and distinctly marked surface ornamentation may belong to some other species than

D. aspera. The detached forms in the Norseman material are very common, and well preserved as a rule.

Pl. II., figs. 26–26.—Dermal spicules with an elongate slender shaft and a saucer-shaped or vasiform expansion at its summit. The expanded head is approximately circular in outline, the margins are smooth, even and slightly elevated (fig. 25) ; in the centre is a small boss or knob which in some cases may project above the level of the margins (fig. 23), in others it is hardly perceptible (fig. 24). Viewed from below, the under surface of the spicule shows one or more concentric growth lines and faint traces of radiating folds reaching a short distance above the edge ; the fractured summit of the shaft and its axial canal are shown in the centre (fig. 26). The axial canal of the shaft is closed at or just below the junction of the shaft and the head, it extends the length of the shaft and opens at its distal apex. There is no indication of canals radiating from the centre in any of these spicular heads. In one specimen the shaft is embraced by a portion of a skeleton spicule of the sponge to which the dermal spicule belonged. The shaft is about 0·2 in length : the expanded heads are 0·075–0·11 in breadth. They belong to a species of *Discodermia* not improbably to the same form as the skeleton spicules described above (pl. II., figs. 9, 10).

Nearly similar dermal spicules are figured by O. Schmidt (1) in *D. dissoluta* from off Barbados at a depth of 56 fathoms : by Carter (2) in *D. lævidiscus* from the Gulf of Manaar, and by Sollas (3) in *D. ornata* a recent sponge of unknown locality. As the Norseman spicules differ in smaller details from those in the species just mentioned, it is probable that they belong to a sponge yet undescribed.

Dermal Spicules of CORALLISTES, O. Schmidt, *and other genera.*

Pl. III., fig. 1.—Dermal spicule with a short shaft and at its summit six horizontally extended rays. The rays are sub-equal when complete and they are traversed by axial canals which extend to the distal ends of the rays. The rays are about 0·18 in length by 0·05 wide. The head of the specimen is 0·39 across. These spicules are common in the Norseman material but generally in fragments. Similar detached spicules are found in the Oamaru deposit, also in the material dredged by the "Egeria" off the S.W. of Australia from a depth of 2,479 fathoms. They also form the dermal layer in several genera of Megamarine and Tetracladine Sponges from the Upper Cretaceous of the South of England and of Germany, and in the recent genus *Corallistes*, O. Schmidt.

Pl. III., fig. 2.—Dermal spicule with a short shaft and five horizontally extended rays at its summit. In this form one of the head rays of the normal trifid remains simple, and the other two

(1.) Die Spongien des Meerbusen von Mexico, Heft. II., 1880, p. 87, pl. V., fig. 2c.
(2.) Ann. & Mag., N. H., ser. 5, vol. VI., 1880, p. 503, pl. VIII., figs. 51c, d.
(3.) Chall. Rep. vol. XXV., p. 297, pl. XXXI., figs. 5, 5a, 5d.

are bifurcate. The rays are nearly straight, slender, and they terminate distally with a small foot-like expansion. The axial canals extend but a short distance from the centre of the spicule. The rays are 0·13–0·22 in length by 0·02 in thickness. In the character of the rays this form resembles the dermal spicules of *Theonella Swinhoei* Gray, as figured by Sollas (Chall. Rep., vol. XXV., p. 284, pl. XXIX., figs. 4, *4a*, *4b*).

Pl. III., fig. 3.—Dermal spicule in which one of the head rays is larger and inequally developed in comparison with the others. The axial canals are short and nearly equal in size. Diameter of the head rays 0·4. Rare.

Skeleton Spicule of VETULINA, O. Schmidt.

Pl. II., fig. 11.—Spicule with four or five rays extending in different directions from a definitely thickened centre. Some of the rays are single, others furcate, their distal ends are slightly expanded where they have been attached to adjoining spicules. In the centre of the spicule is a shield shaped prominence. Axial canals are not present. The spicule is 0·14 in breadth. Similar spicules are present at Oamaru, they have been referred to the recent genus *Vetulina* (op. cit., p. 240, pl. XIII., figs. 31–33). Rare.

Spicules of unknown Sponge.

Pl. III., figs. 6, 7.—Minute spicules, with a short central axis or shaft from either end of which three or four acutely pointed rays extend obliquely. Each ray has two whorls of small spines. Canals are not visible. Diameter of the spicule, including the rays, 0·15: length of the terminal rays 0·075. I have not met with any description of this form in connection with either fossil or recent sponges.

Dermal (?) *Spicules,* DACTYLOCALYCITES, Carter: PLACOLITHIS, *pars.* EHRENBERG.

Pl. III., figs. 4, 5.—Thin siliceous plates of oval elliptical outlines with smooth surfaces and a series of straight or slightly curved canals radiating from the central area to the circumference. The margins in all the specimens in this deposit are imperfect, either from having been worn away or from not having reached full development: they now show the free distal ends of the radiating canals, with tongue-like extensions and deep alternating large and small notches between. In the centre of the spicules the canals are disposed so as to form a double arch, with their apices nearly meeting, from this point the canals radiate fan-like towards each end. When the spicules are complete their margins are even and continuous all round, the distals ends of the canals are closed, and the notches now form oval or hour-glass shaped apertures ranged round and just within the margins of the plate. The canals vary

in number in different specimens from 17 to 24. The spicules are 0·25–0·3 in length, by 0·12–0·18 in breadth.

These detached spicules are widely distributed. As fossils they have been found in the Jurassic radiolarian marls of Hanover (1), in the Upper Greensand of (2) Devonshire, and (3) Wiltshire, the Upper Cretaceous of (4) Westphalia (zone of *Bel. mucronata*) and in the same zone at (5) Horstead, Norfolk: in the Tertiary radiolarin deposits of (6) Barbados, and in similar deposits at (7) Oamaru, New Zealand. They have also been dredged up from a depth of over 13,000 feet in the (8) Indian Ocean and from off the S.W. coast of Australia at a depth of 3,000 fathoms. In the Norseman material they are fairly common. They are supposed to be the dermal spicules of a sponge, which is as yet, unknown.

Spicules of Hexactinellida.

Pl. III., fig. 8.—A small fragment of the skeleton of a dictyonine hexactinellid. The spicular frame is robust, its surface smooth, the nodes are simple, *i.e.*, not octahedral, and the axial canals are considerably enlarged. The spicular framework is 0·035 in thickness and the distance from node to node 0·11. Minute fragments of a similar character are common in the Norseman material.

Pl. III., fig. 9.—A detached five-rayed spicule, the rays robust, tapering, and blunt at their distal ends. The axial canals are enlarged and open at the end of the rays. Length of rays, 0·14: thickness 0·045.

Pl. III., fig. 10.—Spicule similar to the preceding, the rays are short and tapering slightly, with rounded ends; the canals are well shown, and in this specimen they terminate within the rays. Length of rays 0·085: thickness 0·04.

Pl. III., fig. 11.—A detached five-rayed spicule with smooth, slightly tapering rays; the axial canals are much enlarged and open at the ends of the rays. Length 0·14 by 0·025.

Dermal Spicules of Rossella, Carter.

Pl. III., figs. 12, 13, 14.—Spicules consisting of an elongate straight shaft, with four straight or slightly curved rays extending at right angles from its summit. They have been compared to a

(1.) Palæontographica, Bd. XXXI., pl. XX., fig. 42.
(2.) Carter. On Fossil Sponge Spicules of the Greensand, etc., Ann. & Mag., N. H., S. 4, vol. VII., p. 123, pl. IX., fig. 40.
(3.) Hinde. Sponge Remains in the Lower and Upper Greensand. Phil. Trans. Roy. Soc., vol. CLXXV., part II., 1885, p. 442, pl. XLIII., fig. 3.
(4.) V. Zittel. Ueber Coeloptychium. Abh. d. k. Akad. d. Wiss. XII., Bd. III., Abth., p. 47, pl. V., figs. 32–35.
(5.) Hinde. Fossil Sponge Spicules from the Upper Chalk., 1880, p. 40, pl. I., fig. 23.
(6.) Bury. Polycystines in the Barbados Chalk deposit, 1862, pl. VII., figs. 1, 2.
(7.) Hinde & Holmes. Sponge Remains in the Lower Tertiary Strata of Oamaru, New Zealand. Linn. Soc. Journ. Zool., vol. XXIV., 1892, p. 236, pl. XIV., figs. 35, 36, 37.
(8.) Ehrenberg. Microgeol. Studien, 1873, p. 147, pl. 36, fig. 9.

section of an umbrella, the shaft representing the handle, and the four rays as so many ribs. For a short distance from the shaft the horizontal rays are connected together by a siliceous membrane, beyond this the rays are quite independent of each other. The angle included by the four rays varies in different specimens from 105° to 120°. Canals, now considerably enlarged are shown both in the shaft and in the rays. These spicules are fairly common in the Norseman material, but they are all very imperfect so that it is not possible to ascertain their dimensions when complete. The longest fragment of a shaft (fig. 12) is 0·27 in length by 0·035 in thickness, and of a ray 0·25 by 0·02. This form of spicule detached was first noticed in the * Upper Chalk of the North of Ireland, and it was considered by the late Dr. Bowerbank to belong to the dermal system of a siliceo-fibrous sponge. Afterwards it was found on the samehorizon (Zone of *Bel. mucoronata*) in (1) Westphalia, (2) Norfolk, and in siliceous rock occuring as an erratic in the Boulder Clay of the Roode Klif, Friesland. In (3), a paper on this rock, the resemblance of these forms to the spicules of the surface of the recent hexactinellid, *Rossella antarctica*, Carter, is pointed out. The Norseman specimens are considerably smaller than those in the (4), recent sponge from South of the Kerguelen Islands and from the South Atlantic, east of Buenos Ayres, and they further differ in having a siliceous membrane or patagium connecting the rays near their junction with the shaft, and in the absence of spines on the rays. In both these features the Norseman umbrella spicules correspond with the fossil forms in the Upper Cretaceous rocks of Germany, the East of England, and the North of Ireland.

Summary.

The sample of soft, white siliceous rock from the Deep Lead (?) at Princess Royal, in the Norseman District, was found on microscopic examination, to consist almost entirely of the spicular remains of siliceous sponges; a large proportion of the spicules are now reduced to minute fragments and detritus, but here and there some fairly perfect or but slightly injured forms have been preserved, and the various kinds of these have been described and figured in the report. No other organic remains beyond those of siliceous sponges have been found in the rock sample, and not a single specimen of radiolaria or diatoms, which are usually associated with sponge spicules in deposits of a similar character has been noticed. There is but a small proportion of inorganic constituents in the rock; these consist of minute dark grains which have not been

* J. Wright. Proc. Belfast Nat. Field Club, 1873–4, ser. 2, vol. I., p. 138, pl. III., fig. 1.

(1.) Zittel. op. cit., p. 46, pl. V., figs. 47–50.

(2.) Hinde. op. cit., 1880, p. 62, pl. I., figs. 29, 30.

(3.) Hinde. Bull. Soc. Belge de Geol. Paléon., etc., vol. III., 1889, p. 257, pl. VIII., figs. 105, 106.

(4.) *See* Chall. Rep. Zool., vol. XXI., p. 139, pl. LV., figs. 9, 13.

determined, microscopic particles of quartz, and a few larger granules of the same mineral which appear to have been partly formed in the rock.

The silica of the spicules is in the same colloidal condition as in recent sponges ; in only a few instances are there indications of incipient change. The spicules are all detached and the various kinds are indiscriminately mingled together in the rock. They are nearly all skeleton spicules : very few of the smaller flesh spicules have been found. With hardly an exception they are well known forms, belonging to Monaxonid, Tetractinellid, Lithistid, and Hexactinellid sponges : the three first mentioned groups appear to be represented in about equal proportions, but the spicules of hexactinellid sponges in the material are comparatively few.

Besides spicules which resemble those of existing sponges, there are many in the deposit closely similar to detached spicules in material dredged from a depth of 3,000 fathoms off the South-West coast of Australia, and also to the spicules in the fossil sponge deposit at Oamaru, New Zealand, which is considered to be Upper Eocene in age.

Some of the spicules of the Norseman material are also present in the Cretaceous rocks of England, Ireland, and Germany. Amongst these are three characteristic and somewhat rare forms : the skeleton spicules of a lithistid sponge (1) *Ragadinia*, sp.: the (2) dermal spicules of a sponge as yet unknown, but probably a Tetractinellid : and the umbrella spicules of the Hexactinellid genus (3), *Rossella*, sp. I found and (4) described these three kinds of spicules many years since in the siliceous material enclosed within a single hollow flint nodule from the Upper Chalk of Horstead, Norfolk. It is worthy of note that the three species of sponge to which these spicules belong should have existed together in the Cretaceous seas of the Northern hemisphere, and should have been found again associated together in Tertiary or Post-Tertiary deposits in the Southern hemisphere.

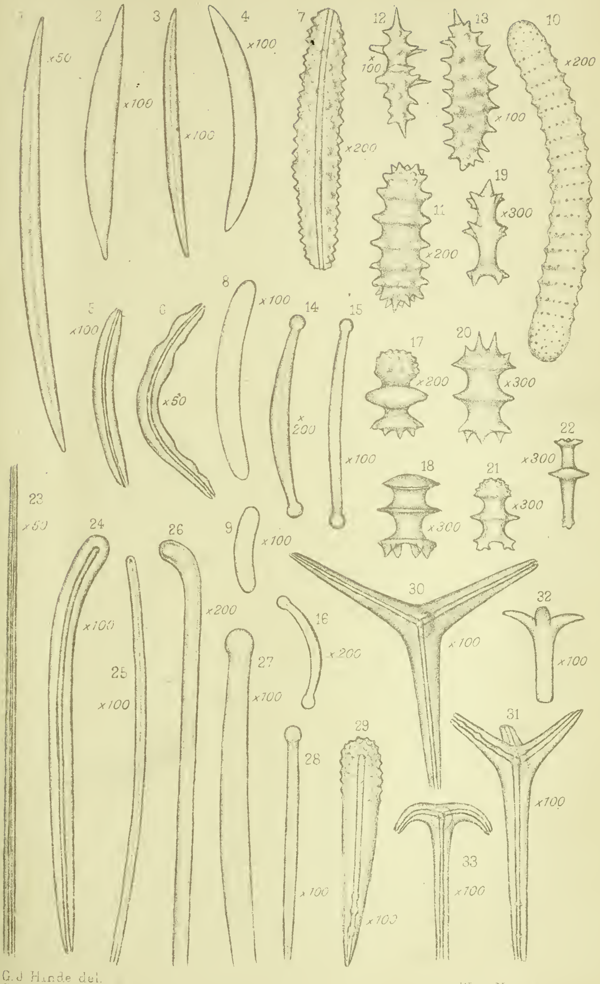
It seems to me that this Norseman sponge-rock is not a merely local deposit, but that it was formed in the open ocean, at some distance from a coast-line, so as to be away from sediment-bearing currents, and probably at a considerable depth. The sponges which furnished the materials of the deposit may have lived, died, and been disintegrated in the same area. As regards the geological age of the rock, I should judge that it is newer than the Cretaceous, but there are no data to indicate the particular periods of the Tertiary or Post-Tertiary in which it may have been formed.

(1.) Pl. II., figs. 7, 8.
(2.) Pl. III., figs. 4, 5.
(3.) Pl. IV., figs. 12, 13, 14.
(4.) Fossil Sponge Spicules from the Upper Chalk of Horstead, 1880, p. 58, pl. V., figs. 1-4; p. 40, pl. I., fig. 23; p. 62, pl. I., figs. 29, 30.

EXPLANATION OF PLATES.

Plate I.

Fig. 1.—Acerate spicule. Probably of *Geodia*—× 50.
,, 2.—Acerate spicule of *Desmacidon* (?)—× 100.
,, 3.—Acerate spicule of *Petrosia* (?)—× 100.
Figs. 4, 5.—Fusiform acerate spicules—× 100.
Fig. 6.—Vermiculate spicule—× 50.
,, 7.—Spined acerate of *Halichondria* (?) × 200.
Figs 8, 9.—Smooth cylindrical spicules of *Strongylophora* (?)—× 100.
Fig. 10.—Curved cylindrical spicule with spined whorls—× 200.
,, 11.—Straight cylindrical spicule with whorls of spines—× 200.
,, 12.—Subcylindrical spicule with whorls of spines—× 100.
,, 13.—Curved cylindrical spicule with whorls of spines—× 100.
,, 14.—Curved tibiella or dumb-bell spicule—× 200.
,, 15.—Straight tibiella of *Forcepia* (?)—× 100.
,, 16.—Curved tibiella spicule—× 200.
,, 17.—Sceptrella spicule of *Latrunculia* sp.—× 200.
,, 18.—Sceptrella spicule with smooth convex summit, *Latrunculia*—× 300.
,, 19.—Sceptrella spicule with median whorl of spines, *Latrunculia* sp.—× 300.
,, 20.—Sceptrella spicule with convex spined summit, *Latrunculia* sp.—× 300.
,, 21.—Sceptrella spicule of *Latrunculia* sp.—× 300.
,, 22.—Sceptrella spicule with cylindrical axis, *Latrunculia* sp.—× 300.
,, 23.—Style spicule of *Tethya* (?) distal portion—× 50.
,, 24.—Style spicule of *Myxilla* (?) sp.—× 100.
,, 25.—Style spicule (imperfect)—× 100.
,, 26.—Style spicule with curved summit—× 200.
,, 27.—Spinulate spicule (imperfect at the distal end)—× 100.
,, 28.—Pin-shaped spicule—× 100.
,, 29.—Style with the upper portion spined, the lower smooth—× 100.
,, 30.—Calthrops spicule with subequal rays—× 100.
,, 31.—Trifid spicule with simple head-rays—× 100.
,, 32.—Trifid spicule (upper portion) of *Stelletta* sp.—× 100.
,, 33.—Trifid spicule of *Geodia* (?) with recurved head-rays—× 100.

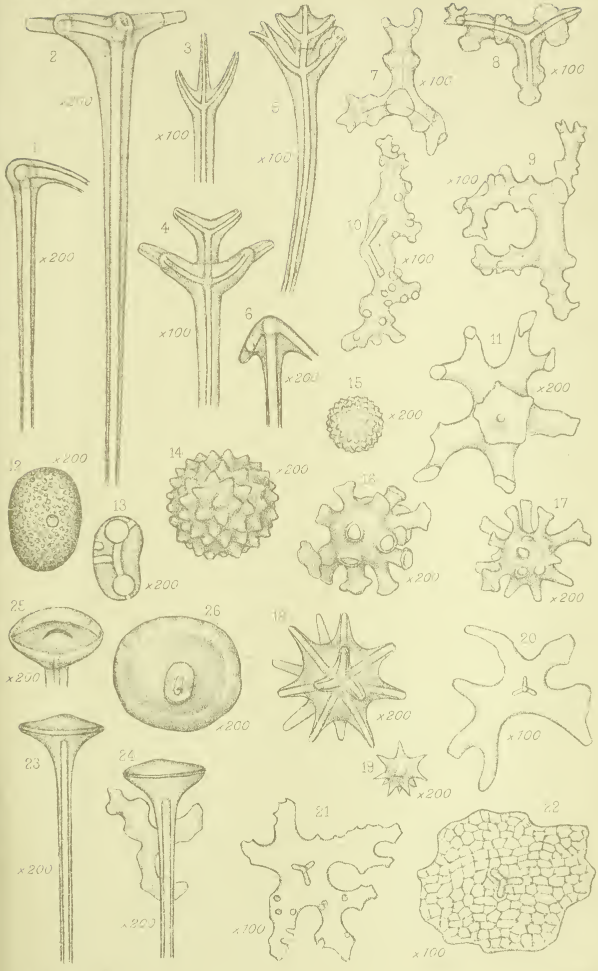


G.J Hinde del.
G.M Woodward lith

West, Newman imp

FOSSIL SPONGE SPICULES NORSEMAN, W. AUSTRALIA.

Geological Survey Plate II.



G. J. Hinde del.
G. M. Woodward lith.

West, Newman imp.

FOSSIL SPONGE SPICULES. NORSEMAN, W. AUSTRALIA.

Plate II.

Fig. 1.—Trifid spicule, abnormal, with only two head-rays—× 200.
,, 2.—Trifid spicule with bifuracted head-rays—× 200.
,, 3.—Trifid spicule of *Craniella* (?) sp. (upper portion)—× 100.
,, 4.—Trifid spicule of *Erylus* (?) sp. (shaft imperfect)—× 100.
,, 5.—Trifid spicule with head rays trifurcate—× 100.
,, 6.—Trifid spicule of *Cydonium* (?)—× 200.
Figs. 7, 8.—Skeleton spicules of *Ragadinia* sp.—× 100.
,, 9, 10.—Skeleton spicules, imperfect, of *Discodermia* sp.—× 100.
Fig. 11.—Skeleton spicules of *Vetulina* sp.—× 200.
Figs. 12, 13.—Reniform spicules of *Geodia*. Fig. 13 shows perforations of boring alga—× 200.
Fig. 14.—Globostellate spicule—× 200.
,, 15.—Globostellate spicule of *Cydonium*—× 200.
Figs. 16, 17.—Globostellate spicule of *Cydonium* sp.—× 200.
Fig. 18.—Globostellate spicule of *Tethya* sp —× 200.
,, 19.—Globostellate spicule of *Tethya* sp.—× 200.
Figs. 20, 21.—Dermal spicules of *Ragadinia* sp.—× 100.
Fig. 22.—Dermal spicules of *Discodermia* showing surface network.—× 100.
Figs. 23–26.—Dermal spicules of *Discodermia* sp. Fig 23 is a lateral view, showing the shaft and a prominent boss in the centre of the head plate. Fig. 24 is a specimen with a portion of a skeleton spicule entangled round the shaft. Fig 25 shows the upper surface of the head plate, and Fig. 26 shows the under surface with the broken stump of the shaft—all × 200.

Plate III.

Fig. 1.—Dermal spicule of *Corallistes* (?)—× 100.

,, 2.—Dermal spicule showing the head-rays (?) *Theonella*—× 100.

,, 3.—Dermal spicule with the head-rays unequally developed—× 100.

Figs. 4, 5.—Dermal (?) spicules of unknown sponge. *Dactylocalycites* Carter. The lower margin of Fig. 4 is partly broken away—× 200.

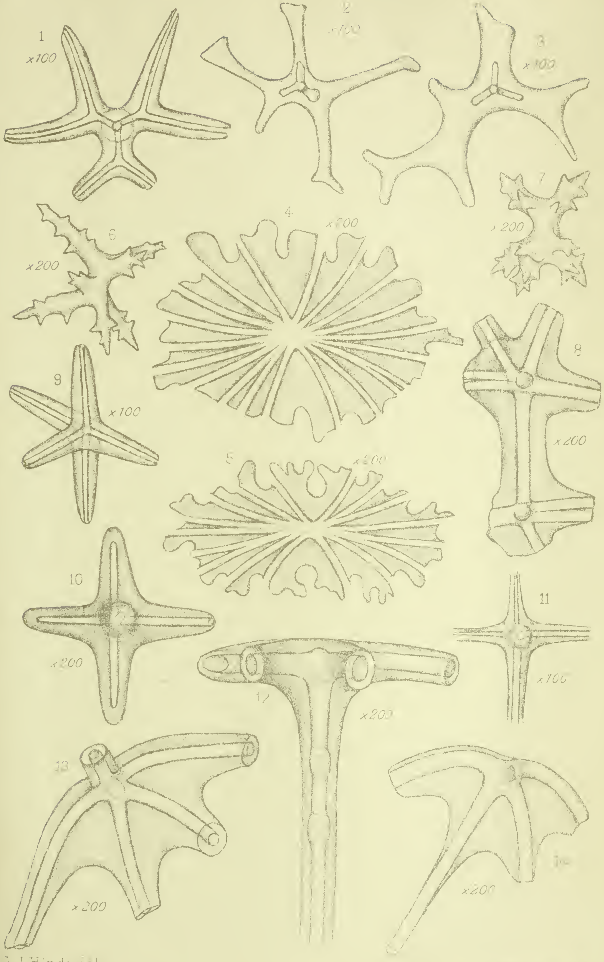
,, 6, 7.—Spicules with spinous rays. Sponge unknown—× 200.

Fig. 8.—Fragment of spicular framework of dictyonine hexactinellid—× 200.

Figs. 9, 10, 11.—Detached five-rayed spicules of hexactinellid sponges. Figs. 9 and 11—× 100; Fig. 10—× 200.

,, 12, 13, 14.—Umbrella spicules of the dermal surface of *Rossella* sp. all fragmentary. Fig. 12 gives a lateral view of the upper portion of the vertical shaft and of the basal portion of the four horizontal rays which radiate from its summit. Figs. 13 and 14 represent the proximal portion of the four horizontal rays with their canals and the patagium connecting the rays; also the broken summit of the vertical shaft—× 200.

The spicules figured on the plates were all derived from a specimen of siliceous rock from the Deep Lead (?) at Princess Royal, Norseman District, Western Australia.



G. J. Hinds del.
G. M. Woodward lith.

West Newman imp.

FOSSIL SPONGE SPICULES, [illegible], W. AUSTRALIA.

11.—Some Fossil Plants from Western Australia.

BY

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The specimens submitted to me were derived from two localities.

The first of these was Mt. Hill (second hill about half mile from Trig. Station) and is represented by two specimens numbered [**8050**] and [**8054**] respectively.

Specimen [**8050**] (3 pieces) is a portion of a coniferous trunk, in which the structure is in part preserved. A transverse section has been made of the specimen, but the preservation of the wood, on microscopic examination, proved to be far too imperfect to permit even of generic determination. It is impossible to determine the age of the beds from which it was derived.

Specimen [**8054**] (2 pieces) has been cut across, and appears to be an arenaceous (?) rock containing a number of thin, eroded fragments or chips of wood, the structure of which is, for the most part, not preserved. Here and there, however, fragments of the wood appear to be petrified, but not sufficiently to permit of determination. The specimen affords no indication of the age of the beds from which it was derived. It is, however, probably *not* Palæozoic.

The second locality was the main road on West boundary of M. 299, 28 chains South of the North-West corner, about three miles South of Mingenew. Altitude about 500 feet above Mingenew. 25 specimens, numbered [**8104 A–Y**], were forwarded to me from this locality.

Otozamites Feistmanteli, *Zigno.*

1881—*Otozamites Feistmanteli,* Zigno, Flora. Foss. Oolit, Vol. II., p. 90, pl. 34, figs. 6–8.

1900—*Otozamites Feistmanteli,* Seward, Jurassic Flora (Brit. Mus. Catal.) Vol. I., p. 221.

1907—*Otozamites Feistmanteli,* Salfeld, Palæontogr., Vol. 54, p. 182, pl. XIX., fig. 14.

This fossil frond is represented by 15 specimens [**8104, A-O**], each exhibiting one or more examples.

The fronds vary considerably in detail, both as regards the shape of the leaflets and the degree of imbrication. There is, however, every reason to believe that they all belong to the same species.

[**8104, D**.] is a good example of one type, in which the pinnules are short and overlap one another. The shape and nervation of the pinnules is well seen. They are attached to the upper surface of the rachis by a broad base, the upper angle of the base being auriculate. This frond appears to be quite identical with that figured by Zigno (*see* above) on fig. 8 of plate 34, from the Lower Jurassic of Italy. This species has also been determined from the Lower Oolite of Britain.

The fronds seen on specimens [**8104 A, B, C, G, I, J,** and **K**], are similar to [**8104 D**] ; the nervation being well seen in [**8104 C**].

In [**8104 F**], also [**8104 E** and **L**], the pinnules are more elongate their length being about 2 c.m. as compared with 1·3–1·4 c.m., in the case of [**8104 D**].

In [**8104 M**] the base of a small frond is seen where some of the pinnules do not exceed 3 m.m. in length, and are more oval in shape.

In [**8104 H**], the pinnules are less imbricated, and this feature is also seen in [**8104 L**], which shows two fronds, one with short, imbricated pinnules similar to [**8104 D**], and another larger frond with longer pinnules, more distant from each other.

In [**8104 N–O**] the pinnules are also less imbricated.

A comparison of the typical specimen [**8104 D**] with the figure given by Kurr of his *Zamites Mandelslohi* (Beitr. foss. Flora Jura format., Württembergs, 1845, p. 10, pl. I., fig. 3), would appear to indicate that the Australian frond may be identical with that occurring in the Lower Oolite of Germany. On the other hand, this matter remains in doubt, for the specimens recently figured under this name, from the Lias of Holzmaden, Württemberg, by Salfeld (Palæontogr., Vol. LIV., 1907, p. 182, pl. XVI., figs. 1*a*, 1*b*, 1*c*) do not appear to be specifically identical with the Australian leaves.

Feistmantel (Mem. Geol. Surv. New South Wales, Pal. No. 3, 1890, p. 147, pl. 28, figs. 9, 9*a* ; refigured by Salfeld, *ibid*, pl. XIX, fig. 14 ; *see* also Jack and Etheridge Geol. and Palæontol. of Queensland 1892, p. 381) has also compared a Queensland fossil, from the Talgai coalfield on the Condamine River, with *Otozamites Mandelslohi* (Kurr). Feistmantel's figure, however, appears to be rather carelessly drawn, or else the specimen is not very well preserved.

There would appear to be a distinct possibility that his frond from Queensland may be identical with the fossils under discussion here, but until his figured specimen (in the Min. and Geol. Mus., Sydney) has been compared with the West Australian leaves, it will be difficult to form any opinion on this point.

So far as I am aware Feistmantel's record is the only species of *Otozamites* as yet found in Australia, though Tenison-Woods

(Proc. Linn. Soc. New South Wales, 1883, vol. VIII., p. 151) has described the same species from another locality in Queensland, *i.e.*, the Darling Downs near Toowoomba.

Thus while there may be some uncertainty as to the identity of the Australian fossils with Kurr's species *Otozamites Mandeslohi*, there is every reason to regard them as specifically identical with the *O. Feistmanteli*, Zigno, of the lower Jurassic of Italy and England. Professor Seward (*ibid.* p. 221) has diagnosed this specie as follows :—" Frond narrow, linear ; pinnæ short and broad, attached to the upper face of the rachis by a broad base, of which the upper corner is slightly auriculate ; the apex is bluntly rounded, the tip being directed upwards. Venation of the *Otozamites* type."

cf. Pagiophyllum. *sp.*

[8104 X–Y]. A portion of a Gymnospermous twig occurs on this specimen associated with a frond of *Otozamites Feistmanteli*, Zigno. The preservation is unfortunately very poor, and it is not possible to determine even the genus with certainty. It appears to stand nearest to the genus *Pagiophyllum*, and with it may be compared the *Pagiophyllum Kurri* of Schimper from the Lias of Germany (*see* Salfeld, *ante*, p. 186, pl. XIX., fig. 1 : also the *Araucaria peregrina* of Kurr, *ante*, p. 9. pl. I., fig. 1). Tenison-Woods has figured (*ante* p. 165, pl. 4, fig. 1) an obscure specimen under the name *Cunninghamites Australis*, sp. nov., which may also be compared with this fossil. Tennison-Wood's specimen was obtained from the Mesozoic beds of Rosewood, Ipswich, Queensland.

Fossil Woods.

[8104 P, Q, S, T, U.] Fragments and casts of fossil stems, in which the structure is not preserved. They are indeterminable, and of no value. The ribbed specimen **[8104 U]** has been cut across, but it is obviously not petrified, and consequently no sections were made of it. It is probably not the pith cast of an Equisetaceous genus, but of Coniferous origin. **[8104 T]** shows what may possibly be a ribbed pith cast, and part of the wood lying more externally. It is, however, impossible to determine its position in the Vegetable Kingdom. **[8104 R]** is a poor cast of a branching or leafy twig, and is also indeterminable.

Indeterminable.

[8104 V–W]. A minute fragment of what appears to be the apical portion of the pinna of a frond. Each pinnule appears to possess a well marked mid-rib, but otherwise the nervation is not seen. The specimen is far too fragmentary and badly preserved to be determinable.

[8104 W] also shows two small seed-like bodies, which are indeterminable.

Conclusions as to the Age of the Beds in the Second Locality.

Of the specimens examined, the fronds of *Otozamites Feistmanteli*, Zigno, and the specimen compared with *Pagiophyllum*, alone afford any evidence as to the age of the beds.

These plants occur in the Jurassic of Europe, and possibly also in (?) Jurassic beds in Queensland. So far as a comparison with the European fossils is concerned, the age would appear to be *earlier* rather than *later* Jurassic. *O. Feistmanteli*, Zigno, occurs in the Lower Jurassic of England and Italy, and possibly also in Germany. *Pagiophyllum Kurri*, with which [**8104 X–Y**] may be compared, is a Lower Jurassic fossil from Germany. As regards the plant bearing beds elsewhere in Australia, the flora of beds, probably of Jurassic age, in Queensland at Talgai (Condamine River), the Darling Downs, and Rosewood, West of Rockhampton, affords the closest comparison with the specimens from Western Australia.

III.—Oolitic Fossils of the Greenough River District, Western Australia,

BY

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I.—Introduction.

Through the kindness of Mr. A. Gibb Maitland, Government Geologist, I have lately had the pleasure of examining a collection of the Oolitic fossils of the Greenough River District.

The principal, and really only important, paper dealing with West Australian Mesozoic fossils, up to a comparatively recent date, was that of the late Charles Moore * of Bath, England. He enumerated a large number of species occurring in that State and of these he described or figured eleven ; nine were described as new, and twenty were believed to be identical with European species. I am now in a position to figure some of these exotic forms mentioned by Moore. In 1904, Mr. F. Chapman published a paper dealing with West Australian Jurassic fossils in the National Museum, Melbourne, † but no new forms were described.

II.—Description of the Species.

CLASS ANNELIDA.

Genus Serpula, *Linnæus*, 1758.
(Systema, Ed. X., p. 786).

Serpula conformis, *Goldfuss.*
(Plate IV., Fig. 1.)

Serpula conformis, Goldfuss, Petrefacta Germaniæ, 2nd Edit., 1862, I., p. 212, pl. 67, f. 13, *a* and *b*.

Obs.—A few small *Serpulæ* are attached to the surfaces of Mollusca. There is no feature to distinguish them from the above carinate Oolitic species.

Moore enumerated *Serpulæ* but without attaching specific names.

Loc.—Tibraddon Station, Greenough River.

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* Moore—Quart. Journ. Geol. Soc., 1870, XXVI., pp. 228–261, pls.
† Chapman—Proc. R. Soc., Vict., 1904, XVI., (n.s.), p. 327.

CLASS BRACHIOPODA.

GENUS RHYCHONELLA, *Fischer*, 1809.
(Notice Foss. Gouv. Moscou, p. 35.)

RHYNCHONELLA VARIABILIS, *Schlotheim*.
(Plate IX., Figs. 3 and 6).

Rhychonella variabilis (Schlotheim), Davidson, Mon. Brit. Oolitic and Liassic Brach., 1852, pt. 3, p. 78 (for synonomy), pl. 15, f. 8–10, pl. 16, f. 1–6.

Obs.—This species was first recorded by Mr. Moore.* In the present collection are biplicate and triplicate individuals, answering to the varities *bidens* and *triplicata* of Phillips.

Loc.—Snake Farm, Greenough River.

CLASS PELECYPODA.

GENUS OSTREA, *Linnæus*, 1758.
(Systema, Ed. X., p. 696).

OSTREA THOLIFORMIS, † *sp. nov.*
(Plate VII., Figs. 2–7.)

Sp. Chars.—Lower valve obtusely conical, irregularly low-dome or cupola-shaped, with a large concave scar of attachment ; test very thick. Upper valve flat, a little concave, or the surface rolling. Cardinal margin in both valves well developed, extending the entire width of the upper valve ; chondrophore comparatively large ; resilium furrows both in the chondrophore and on cardinal margin are strong. Adductor scar in the upper valve oblique and transversely ovate, with exsert lower margin. Well developed latilaminæ on the exterior of both valves.

Obs.—There are ten examples of this oyster in the collection. It is a solid and substantial, although not large form ; one specimen is sub-lobate, the others irregularly round, or oval, in marginal outline. It may possibly belong to one of Bayle's sections of the Genus *Pycnodonta* or *Rhynchostreon*. In the works and collections at my command I am unable to find any species precisely like it but the nearest is *O. akkabensis*, Krumbeck,‡ from the Syrian " Glandarienkalk."

A second species of oyster is possibly present (Pl. IX., fig. 2). It is an upper valve, flat and deltoid in outline, not unlike the same valve of the Kimmeridgian *O. deltoidea*, Sby., but rather less deltoid.

Loc.—Tibraddon and Sandspring Stations, Snake Farm, Greenough River ; Fossil Hill, two miles East of Moonyoonooka Railway Station.

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* Moore—Quart. Journ. Geol. Soc., 1870, XXVI., pp. 231, 232, pl. 10, f. 11 and 12.

† *Tholus*—a dome or cupola.

‡ Krumbeck—Beitrage Pal. Geol. Oster.—Ung. Orients, 1905, XVIII., Heft 1 and 2, pl. 12, f. 1 and 2.

GENUS ALECTRYONIA, *Fischer*, 1806.
(Bull. Soc. Imp. Nat. Moscou, VIII.)

ALECTRYONIA MARSHII, *J. Sby.*, *sp.*
(Plate IV., Figs. 5–7 ; Pl. V., Fig. 4).

Ostrea diluviana, Parkinson, Organic Remains, etc., 1811, III., p. 217, pl. 15, f. 1.

Ostrea Marshii, J. Sowerby, Min. Conchol., 1816, I., p. 103, pl. 48.

Ostrea Marshii, Goldfuss, Petrefacta Germaniœ, 1833, II., lief. 4, pl. 73.

Ostrea Marshii ,Morris and Lycett, Mon. Moll. Gt. Oolite, 1854, pt. 3, p. 126, pl. 14, f. 2, 2*a*.

Ostrea Marshii, Moore, Quart. Journ. Geol. Soc., 1870, XXVI., p. 232.

Alectryonia Marshii, Fischer, Man. Conch. et Pal. Conch., 1886, fas. X., p. 926, f. 690.

Ostrea Marshii, Muller in Bernhardt's Deutsch–Ost–Afrika, 1900, VII., p. 16, f. 1, 1*a*.

Obs.—There are several specimens, and all may pass as varieties of this well known and widely spread shell, " very variable in form," as James Sowerby said, and shown in Goldfuss' beautiful figures. Both the ovately oblong and fan-shaped varieties are present, and the zig-zag frontal edges are also strongly in evidence. Our specimens accord best with Goldfuss' figures *a*, *b*, *f*, and perhaps *k*. The elevated adductor is also very apparent in one. The area, as in foreign examples, is triangular and shell-like and vertically divided by a central wide chandrophore.

Locs.—Tibraddon and Sandspring Stations, Greenough River.

GENUS CTENOSTREON, *Eichwald*, 1868.
(Lethæa Rossica, 1868, II., p. 455.)

CTENOSTREON PECTINIFORMIS, *Schl.*, *sp.*

Ostracites pectiniformis, Schlotheim, Petrefactenkunde, 1820, I., p. 231.

Ctenostreon pectiniformis, Eth., fil., Rec. Austr. Mus., 1901, IV., No. 1, p. 14, pl. 3 (for synonomy).

Ctenostreon pectiniformis, Chapman, Proc. R. Soc. Vict., 1904, XIV., (n.s.), pt. 2, p. 329, pl. 30. f. 1.

Obs.—Five examples in a poor state of preservation add little to our previous knowledge of Australian form of this species. One has the fistulous spines produced into regular elongate tubes, as shown in one of Lycett's figures.*

Locs.—Tibraddon and Sandspring Stations, Greenough River ; Fossil Hill, two miles East of Moonyoonooka Railway Station.

* Lycett—Suppl. Mon. Moll. Gt. Oolite, 1863, pl. 29, f. 1.

GENUS PECTEN, *O. F. Müller*, 1776.
(Zool. Donicæ Prod., p. XXXI.)

PECTEN (?) CINCTUS, *J. Sowerby*.
(Plate IX., Fig. 1).

Pecten cinctus, J. Sowerby, Min. Conchol., IV., p. 96, pl. 371.

Pecten cinctus, Moore, Quart. Journ. Geol. Soc., 1870, XXVI., pp. 230, 231, and 232.

Pecten cinctus, Chapman, Proc. R. Soc. Vict., 1904, XVI. (n.s.), pt. 2. p. 328.

Obs.—The name *P. cinctus*, J. Sby. appeared in Moore's list of West Australian Oolitic fossils, but no complete description of either the British shell, or its supposed Australian analogue has, so far as I am aware, appeared. The original figure displays a shell defective in the region of the auricles and cardinal margin, whilst all the West Australian specimens within my knowledge are in a poor or incomplete state of preservation. In all I have nine specimens before me, seven forming a portion of the present collection and two in the Australian Museum ; the largest of these measures seventeen centimeters by sixteen and a half.

I do not by any means feel satisfied our Australian shells are Sowerby's species. Sowerby said the valves of the British shell were of nearly equal convexity, but in the present instance the valves are very far from being nearly equally convex ; indeed five are actually plano-convex.

The shell is sub-orbicular, more or less plano-convex, one valve moderately convex, the other flat, or nearly so ; the test is thick, but as a rule much exfoliated. In the convex valve, one of the auricles (? anterior) is flat and wing-like, undivided from the body of the shell, and possibly slightly falcate along the outer margin. On the flat valve one auricle (? anterior) is triangular with a strongly falcate, or even segmoidal outer margin. The other ear of the same valve, of which a portion is still visible on one specimen, is, judging from the direction of the ornamenting laminæ, rectangular ; one of the flat valves is ornamented with fine concentric lines. It may be pointed out that Sowerby's figure corresponds to the flat valve of our shells.

Locs.—Tibraddon Station ; a quarter of a mile North-West, and half a mile North of Woolanooka ; Sandspring Station, Greenough River ; Snake River, Greenough River District.

PECTEN (?), *sp.*
(Plate VIII., Figs. 5 and 6.)

Obs.—I previously refer to *Pecten* two small slightly oblique valves, almost round in outline, very moderately convex and with small flat ill-defined triangular auricles. A very large number of strong costæ decorate the surfaces, either all of one size or alter-

nately larger and smaller, the latter interpolated, the former sometimes bifurcate. The umbo was acute and overhung the cardinal margin.

I believe this to be one of those unsatisfactory forms oscillating between *Pecten* and *Radula* and in all probability in want of a particular generic designation.

Loc.—Sandspring Station, Greenough River.

GENUS RADULA, *Klein*, 1753.

(Tent. Meth. Ostrac., p. 135).

RADULA DUPLICATA, *J. de C. Sowerby*.

(Plate VIII., Figs. 7 and 8).

Plagiostoma duplicata, J. de C. Sby., Min. Conchol., 1827, V., p. 114, pl. 559, f. 3.

Lima duplicata, Morris and Lycett, Mon. Moll. Gt. Oolite, 1853, pt. II., p. 26, pl. 3, f. 6 and 6*a*.

Obs.—Of rather common occurrence throughout the hand specimens of matrix are portions of a small *Radula*. The auricles always either hidden or defective, and all that can be said of the specimens is that the size is small, the outline oblique, and the surface covered with many radiating, direct, strong, angular costæ ; between these are very much finer ribs, occupying the centres of the valleys or inter-costal spaces, and not reaching to the umbos.

In their present condition it is impossible to distinguish these fossils from the corresponding portions of *R. duplicata*.

Locs.—Sandspring Station, and a quarter of a mile South of Tibraddon Station, Greenough River.

GENUS MODIOLA, *Lamarck*, 1799.

(Min. Soc. Hist. Nat. Paris, 1799, p. 87).

MODIOLA MAITLANDI, *sp. nov.*

(Plate V., Fig. 1 and 2).

Sp. Chars.—Shell large, bold, gibbous, oblique, strongly modioliform, and transversely elongate. Cardinal margins straight, about three-quarters the length of the shell ; valves convex along the obtuse diagonal ridges, which are at first nearly parallel to the cardinal margins, and then curve outwards and downwards, the valves steep on the fore side, flat on the hind surface. Anterior ends very small, almost undeveloped, the margin bluntly rounded. Ventral margins long, concave in the centre, convex at both ends. Sculpture of fine concentric lines and broad latilaminæ of growth.

Obs.—This fine shell, of which the interior is unknown, appears to be an addition to the West Australian list. For an Oolitic *Modiola* its size appears to be unusual, and quite vies with that of

M. alatus, Krumbeck, * of the Glandarienkalk of Syria ; it differs from this, however, in the possession of pronounced diagonal ridges and insinuated ventral margins.

M. Maitlandi is not unlike some *Myoconchæ*, particularly Cretaceous species. Even amongst *Modiolæ*, the size is more akin to that of the recent species *Modiola vagina*, Lamk, than it is to most fossil forms. It is named in honour of Mr. A. Gibb Maitland, Government Geologist.

Locs.—Tibraddon and Sandspring Stations, Greenough River.

Genus Cucullæa, *Lamarck*, 1801.

(Système, p. 116).

Cucullæa semistriata, *Moore*.

(Plate VI., Figs. 1 and 2 ; Pl. VIII., fig. 3).

Cucullæa semistriata, Moore, Quart. Journ. Geol. Soc., 1870, XXVI., 250, pl. 14, f. 3.

Cucullæa semistriata, Eth. fil., Ann. Rept. Dept. Mines, N. S. Wales for 1889 (1890), p. 239.

Sp. Chars.—Shell obliquely oblong, quadrate, robust, inflated. Cardinal margins considerably less than the width of the shell ; umbonal regions high, prominent ; umbos depressed, flattened above, the apices curving over the area ; the latter wide, with sharp margins. and deeply excavated, the ligamentary grooves widely V-shaped, about fourteen on each moiety of the area. Anterior ends obtuse, the margins very slightly rounded or almost truncate ; anterior slopes slightly flattened but steep. Posterior ends obliquely produced, obtusely pointed ; margins above oblique, below obtusely rounded ; posterior slopes forming scalene triangles, long, slightly concave ; diagonal ridges prominent above. Articules strong ; medium denticles numerous and oblique ; lateral teeth three on each side, large and strong, the upper one practically horizontal, the median slightly oblique, the lower decidedly oblique. Sculpture of deep latilaminar grooves with between them finer concentric lines, crossed on the anterior slopes by fine radii producing a cancillated surface.

Obs.—Moore speaks of the " hinge-area bounded by a lanceolate straight space," which does not appear on the specimens before me. This species very closely resembles Goldfuss' illustration† of *C. oblonga*, J. Sby. So far as I have been able to isolate the articulus, the shell appears to be a true *Cucullæa*, at the same time the muscular scars have not been seen. *C. semistriata* is represented by the greatest number of individuals, and it may be distinguished generally by its oblong-quadrate robust form.

* Krumbeck—Beitrage Pal. Geol. Osterr.—Ung. Orients, 1905, XVIII., left 1 and 2, pl. 11, f. 4 and 5.

† Goldfuss—Petrefacta Germaniæ, Thiel 2, pl. 123, f. 2.

Locs.—Tibraddon and Sandspring Stations and half a mile North of Woolanooka, Greenough River ; Fossil Hill, two miles East of Moonyoonooka Railway Station, Greenough River District.

CUCULLÆA TIBRADDONENSIS, *sp. nov.*

(Plate V., Fig. 3 and 4).

(?) *Cucullæa, sp.* Moore, Quart. Jour., Geol. Soc., 1870, XXVI., p. 250.

Sp. Chars.—Transverse obliquely oblong, produced posteriorly only moderately inflated in the umbonal region. Cardinal margins about two-thirds the length of the shell ; umbos depressed, flattened above. Area narrow, deep ; ligamentary grooves five on each area half. Anterior ends rather obtuse, the margins almost vertical above, rounded below, the antero-cardinal junctions forming a right angle ; anterior slopes obtuse. Posterior ends long, produced, narrow, wedge-shaped, the margins all rounded, and without postero-cardinal angles ; diagonal ridges sharp umbonally becoming obtuse in their downward course and dying out ; posterior slopes slightly concave. Sculpture of latilaminæ, which are strong and corrugated on the posterior extremities, with intermediate finer concentric lines, and umbonal radii.

Obs.—Moore recorded four species of *Cucullæa* from West Australia, viz., *C. oblonga*, J. Sby., *C. inflata*, Moore, *C. semistriata*, Moore, and a fourth, to which no name was given, this last "distinguished by its being much narrower or transversely elongated." There is a strong probability of this being the shell in question. It may be at once distinguished from the others by its wedge-like produced posterior end.

Locs.—Tibraddon and Sandspring Stations, Greenough River.

CUCULLÆA, *sp.*

(Plate VII., Fig. 1 ; Pl. VIII., Figs. 1 and 2).

Obs.—The collection contains four single valves that may be Moore's first species of West Australian *Cucullæa* (*C. inflata*), although neither of them appear to be sufficiently inflated to answer to his figures. The shells before me possess an outline quite dissimilar to those referred to *C. semistriata*. It is quadrate, somewhat obliquely so, longer than broad. The cardinal margins, as Moore says of his *C. inflata*, are shorter than the width of the shell, and the umbos median and much elevated. The largest specimen is by no means perfect, but the anterior and posterior ends appear to be truncate, and there is certainly a strong posterior diagonal ridge, again as described by Moore, and a wide posterior slope. The area is wide and very high, with many ligamental furrows (more than fifteen). The entire valve is sculptured with fine concentric lines on wide latilaminæ, and anterior radii.

Moore recorded*, but neither described nor figured, the European *C. oblonga*, J. Sby.† as a West Australian species. He said "*C. oblonga* is the most frequent [species] of this genus." Sowerby's figure is drawn from a point of view very difficult for determinative purposes, but notwithstanding this, I have not seen a *Cucullœa* from West Australia I could refer to it, although the present form approaches nearest.

Loc.—Fossil Hill, two miles East of Moonyoonooka ; Sandspring Station, Greenough River.

GENUS TRIGONIA, *Bruguière*, 1789.

(Encycl. Méthod. I., pl. 14).

TRIGONIA MOOREI, *Lycett.* ‡

(Plate IV).

Trigonia Moorei, Lycett. Brit. Fos. Trigoniæ, No. 4, 1878, p. 151, fig.

Trigonia Moorei, Moore, Quart. Jour. Geol. Soc., 1870, XXVI., p. 254, pl. 14, f. 9 and 10.

Trigonia Moorei, Eth. fil., Rec. Austr. Mus., 1904, No. 4, pl. 27, f. 3 and 4.

Sp. Chars.—Shell irregularly quadrate, posteriorly oblique ; valves generally compressed, in advanced age becoming inflated ; anterior cardinal margins short, steep ; posterior cardinal margins moderately long ; umbonal regions high ; umbos much more anterior than posterior, fine, very slightly opisthogyrate ; escutcheon elongately cordate, almost reaching to the posterior cardinal angles, bounded by fairly well pronounced carinæ ; ligamentary aperture heart-shaped, short. Anterior ends small comparatively, entirely confined between the upper parts of the cinctures and the anterior margins which are rounded ; posterior ends much compressed, the margins short and oblique ; cinctures on leaving the umbos at first nearly vertical, then sweping down so as to just miss the postero-ventral angles, broad and shallow ; diagonal ridges prominent ; posterior slopes flattened, each traversed by a median radial groove. Ventral margins well rounded on the anterior side, and nearly straight medianally to the postero-ventral angles. Sculpture anterior to the cinctures of 20-23 sharp, outstanding, concentric lyræ, separated by wide, flat valleys, the former almost vertical along the anterior margins ; on arriving at the cinctures the lyræ rise into flat transverse nodes, but pass over the former as faint flat laminæ, terminating at the diagonal ridges as prominent transverse echinating nodes ; posterior slopes bear fine curved radii and transverse ridges giving rise to a scabrous surface, the points of intersection nodose ; on the escutcheon this scabrous sculpture occurs at its very apex immediately under the umbos, the remainder

* Moore—Quart. Journ. Geol. Soc., 1870, XXVI., pp. 231, 250.
† Sowerby—Min. Conchol., 1818, III., p. 7, pl. 206, f. 1 and 2.
‡ Non *T. Moorei*, Garich.

of the surface bearing lines. Articules much arched, strong ; hinge plates thick ; nymphæ small, erect ; triangular cardinal callosity of the left valve well developed and projecting horizontally above, but distinctly hollowed below ; posterior tooth of the right valve long, fitting into a correspondingly long and deep socket of the left valve ; posterior tooth of the left valve also large and projecting.

Obs.—This, to us well-known, shell has not been described before in detail. It is one of the most characteristic West Australian Mesozoic fossils and occurs at certain localities in great profusion. The original notes published by Mr. Moore were furnished by Dr. J. Lycett, who compared *T. Moorei* with *T. costata*, J. Sby., of the European Lower Oolite and found it to differ as follows :—(1) generally more compressed ; (2) escutcheon narrower and longer (3) posterior slopes (Lycett's area) larger, more convex, more expanded, and bipartite, the median carinæ replaced by grooves ; (4) inner carinæ (bounding the escutcheon) slightly nodular and inconspicuous ; (5) anteally the lyræ approach the valve margins almost perpendicularly ; (6) no distinct anterior truncation ; (7) diagonal ridge of the right valve stronger than that of the left. Of these characters the last does not appear to hold good when a number of specimens are examined.

Mr. F. L. Kitchin considers *T. Moorei* to be of "essentially similar aspect" to his *T. dhosœnsis** of the Cutch Jurassic fauna, but on a close examination the two shells need not for a moment be mistaken for one another.

There is a much higher degree of gibbosity, or inflation, in the united valves of old shells, than in those of young and median growth. In old individuals also the scabrous surface of the posterior slopes is much accentuated. Other than these points the species appear to maintain its character free of variation. The largest example to come under my notice measured two and a half inches along the cinctures from umbos to ventral margins. In absolutely unworn specimens, the interlyrate concentric striæ on crossing the cinctures rise into delicate frills.

Locs.—Tibraddon and Sandspring Stations, Greenough River ; Fossil Hill, two miles East of Moonyoonooka Railway Station ; quarter mile North-West and half mile North of Woolanooka, Greenough River and Snake Farm, Greenough River.

Genus Astarte, *J. Sowerby*, 1816.

(Min. Conchol., II., p. 85).

Astarte Cliftoni, *Moore*.

(Plate V., Figs. 5–8 ; Pl. VI., Fig. 3).

Astarte Cliftoni, Moore, Quart. Journ. Geol. Soc., 1870, XXVI., p. 249, pl. 13, f. 10.

Sp. Chars.—Shell ovately-trigonal, inequilateral in the extreme, compressed ; cardinal margins highly arched, strongly re-

* Kitchin—Jurassic Fauna of Cutch (Pal. Ind.), III., pt. 2, No. 1, 1903, p. 29, pl. 3, f. 1 and 2.

versed V-shaped, short on the anterior sides, and very long posteriorly. Umbos quite anterior, fine, sharp, and depressed ; lunule large, deep, ovate cordiform ; escutcheon very long, deep and narrow ; ligamentary aperture less than half the length of the escutcheon, ligament stout. Anterior ends merely fractional from the advanced position of the umbos, their brief margin quite rounded ; anterior diagonal ridges short, curved very sharp, bounding the lunule. Posterior ends consisting of what is tantamount to the entire valves, flattened, the margins rounded, forming by their junctions with the oblique cardinal margins approximate angles of 15° ; posterior slopes quite inconspicuous. Sculpture of very numerous, sharp, close, regular, concentric lyræ.

Obs.—The ovately-trigonal outline, long obliquely arched cardinal posterior margins, and compressed valves, render this an easily recognised shell. It is only to be distinguished from *A. subtrigona*, Münster,* of the Wurtemberg Inferior Oolite, by possessing a rather more oblique outline and more compressed valves. I have seen the articulus of the left valve, and it is characteristically astartiform ; the central socket for the reception of the right central cardinal is remarkably large.

Loc.—Tibraddon Station, Greenough River.

CLASS GASTEROPODA.

Genus Pleurotomaria, *Defrance*†, 1824.

(Tableau, p. 114).

Pleurotomaria Greenoughensis, *sp. nov.*

(Plate VIII., Figs. 9 and 10).

Sp. Chars.—Shell conical. gradate ; whorls six, step-like, lower portion the larger moiety and slightly oblique, the upper half nearly horizontal ; band probably represented by a slight groove around the middle of each whorl. Sculpture spiral.

Obs.—A very unsatisfactory specimen, but as univalves appear to be so scarce in collection of West Australian Mesozoic fossils, it was thought advisable to notice it. The base is incomplete, but the mouth was probably transversely oval and oblique. The finer details of sculpture also are not preserved.

Loc.—Sandspring Station, Greenough River.

CLASS CEPHALOPODA.

Genus Dorsetensia, *S. S. Buckman*, 1892.

(Mon. Inf. Oolite Ammonites, pt. VI., p. 302).

Dorsetensia Clarkei, *Crick*.

(Plate VI., Fig. 4 ; Plate IX., Fig. 7).

Ammonites radians, Moore (non Schlotheim), Quart. Journ. Geol. Soc., 1870, XXVI., pp. 230, 231, 232 ; pl. 15, f. 2.

Ammonites (*Dorsetensia*) *Clarkei*, Crick, Geol. Mag., 1894, I., (4), p. 388, pl. 12, f. 2, *a–c*.

Obs.—Seven examples of this species are before me in varying states of preservation, the largest with a diameter of three and a

* Munster—In Goldfuss, Petrefacta Germaniæ, Ed. 2, 1862, II., p. 183, pl. 134, f. 17, *a* and *b*. † Restricted, Fischer.

quarter inches. Two of the specimens exhibit five and a half whorls and still incomplete. In casts the costæ disappear on the flanks at about the sixth whorl.

Locs.—Tibraddon Station and Snake Farm, Greenough River; Fossil Hill, two miles East of Moonyoonooka Railway Station.

Genus Perisphinctes, *Waagen*, 1869.

(Benecke's Geogn-pal. Beiträge, 1869, II., p. 248).*

Perisphinctes championensis, *Crick* ?

Ammonites (*Perisphinctes*) *championensis*, Crick, Geol., Mag., 1894, I., (4), p. 436, pl. 13, f. 2 *a* and *c*.

Ammonites (*Perisphinctes*) *championensis*, Chapman, Proc. R. Soc. Vict., 1904, XVI. (n.s.), p. 331, pl. 30, f. 2.

Obs.—Two imperfect specimens are referred to this species one with a diameter of five and a half inches. Both exhibit the superumbilical nodes and fasciculate costæ of this and *P. robiginosus*, Crick, † indeed, it is very difficult to distinguish the one from the other.

Loc.—Tibraddon Station, Greenough River.

Genus Sphæroceras, *Bayle*.

Sphaeroceras semiornatus, *Crick* ?

(Plate IX., Fig. 8).

Ammonites Brocchi, Moore (non J. Sby.), Quart. Journ. Geol. Soc., 1870, XXVI., pp. 231, 232, pl. 15, f. 4.

Ammonites (*Sphæroceras*) *semiornatus*, Crick. Geol. Mag., 1894, I. (4), p. 434, pl. 13, f. 1, *a* and *b*.

Obs.—A single impression or mould in limonite may represent this species judging by the remains of the sculpture; the superumbilical or dorsal tubercle-ribs passing into more numerous median or ventral costæ are quite apparent.

Loc.—Tibraddon Station, Greenough River.

Genus Nautilus, *Breynius*, 1732.

(Dissert. de Polythal).

Nautilus perornatus, *Crick*.

Nautilus semistriatus, Moore (non D'Orb.). Quart. Journ. Geol. Soc., 1870, XXVI., pp. 230, 231, 232.

Nautilus perornatus, Crick, Geol. Mag. 1894, I. (4), p. 386, pl. 12, f. 1 *a* and *c*.

Obs.—In the present collection are three examples imperfect and poorly preserved, but still showing that the shell attained a

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* *Fide* Neumayr.

† Crick—Geol. Mag., 1894, I. (4), p. 438, pl. 13, f. 3, *a*, and *b*.

large size. The largest consists of a portion of the venter and one flank, the former bearing revolving costæ, and the latter coarse lines of growth. This specimen measures round the venter sixteen inches, and across the same, four and a half inches. The second example is similar but smaller, whilst the third is part of a flank and half a venter again exhibiting the revolving costæ, but in this instance on both, with septal sutures and cameræ. The third example is a much smaller specimen, about double the size of Mr. Crick's figure.

Loc.—Tibraddon Station, Greenough River and Fossil Hill, two miles East of Moonyoonooka Railway Station.

EXPLANATION OF PLATE IV.

TRIGONIA MOOREI, *Lycett.*

Fig. 1.—A full grown specimen of a left valve showing the *lyræ* passing across the cincture as frills.

,, 2.—A similar valve the lyræ terminating in tubercles before passing over the cincture ; the posterior slope with semi-concentric lyræ and median shallow radial groove.

,, 3.—Slightly smaller example with the eschinated sculpture of the posterior slope and well developed nodes along both sides of the cincture.

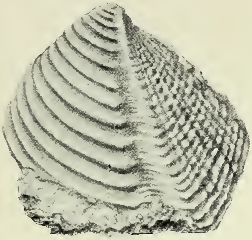
,, 4.—A similar specimen to Fig. 3.

,, 5.—Articulus of a left valve showing the projecting cardinal socket-like callosity and teeth.

,, 6.—Internal cast of the right valve.

,, 7.—Internal cast of the united valves seen from above.

,, 8.—The same seen from the anterior.



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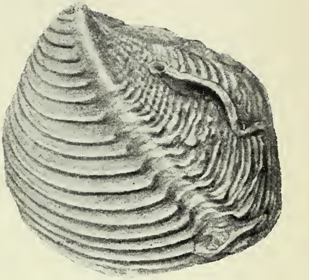

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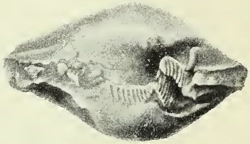

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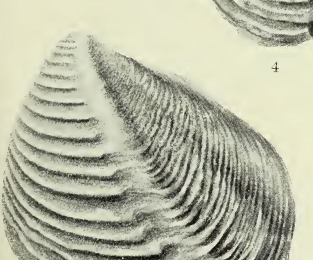

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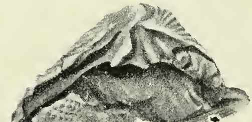

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EXPLANATION OF PLATE V.

MODIOLA MAITLANDI, *Eth. fil.*

Fig. 1.—Left valve of a well preserved example.

,, 2.—The united valves seen from above.

CUCULLÆA TIBRADDONENSIS, *Eth. fil.*

,, 3.—Left valve slightly imperfect.

,, 4.—The united valves seen from above, exhibiting the area.

ASTARTE CLIFTONI, *Moore.*

,, 5.—Right valve showing the general outline and close regular concentric lyræ.

,, 6.—United valves seen from above with the escutcheon and ligament.

,, 7.—Anterior end of the united valves with the lunule.

,, 8.—Articulus of the left valve.


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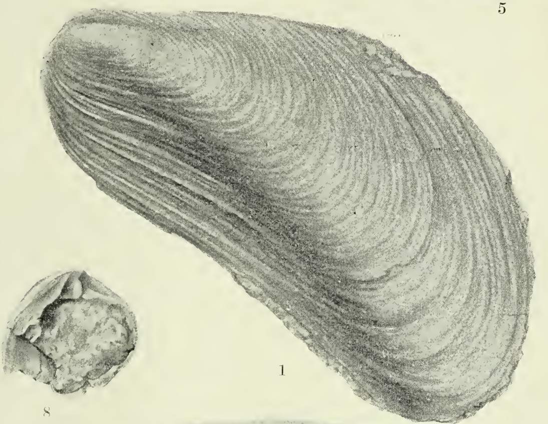
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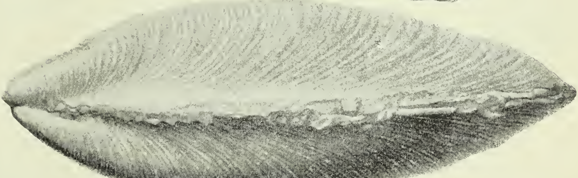
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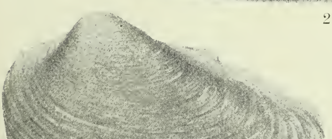
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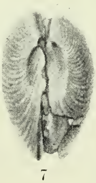
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EXPLANATION OF PLATE VI.

CUCULLÆA SEMISTRIATA, *Moore.*

Fig. 1.—Left valves nearly complete.

,, 2.—United valves seen from above, exhibiting the area.

ASTARTE CLIFTONI, *Moore.*

,, 3.—Right valve of an individual with fine lyræ.

DORSETENSIA CLARKEI, *Crick.*

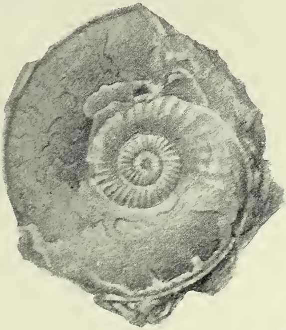
,, 4.—An imperfect shell exhibiting costæ on the inner whorls, also sutures and keel of the venter.

ALECTRYONIA MARSHI, *J. Sowerby.*

,, 5.—Interior of portion of a fan-shaped (?) valve with the elevated adductor scar.

,, 6.—Exterior with subradiating costæ and partial view of the zig-zag frontal edge.

,, 7.—Interior of a subtriangular valve with the elevated adductor scar, and large triangular area and its wide chondrophore.



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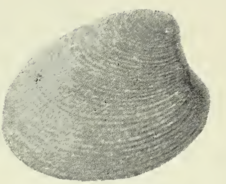

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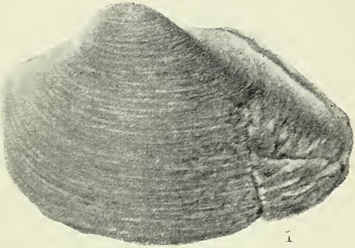

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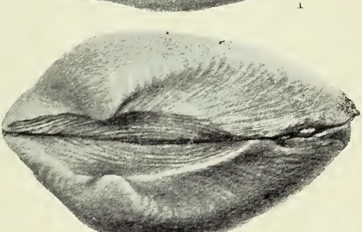

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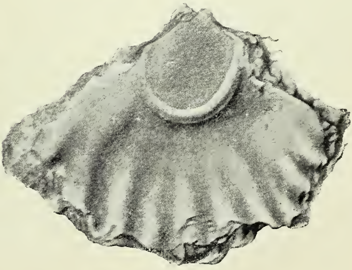

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EXPLANATION OF PLATE VII.

CUCULLÆA, *sp.*

Fig. 1.—Left valve nearly complete with latelaminæ bearing subordinate concentric lines, crossed at the anterior end by fine radii. (This may be *C. inflata*, Moore.)

OSTREA THOLIFORMIS, *Eth. fil.*

" 2.—Exterior of flat valve.

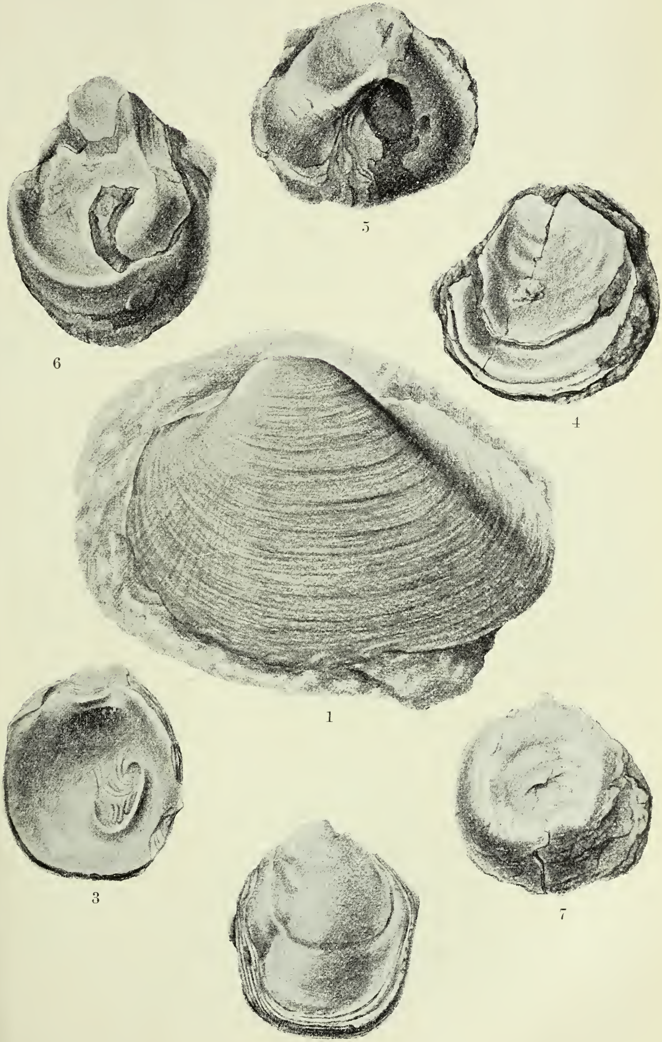
" 3.—Interior of the same valve with the elevated adductor scar rim and *Serpulæ.*

" 4.—Another example of a flat valve.

" 5.—The attached dome-shaped valve more or less exfoliated.

" 6.—A much exfoliated attached valve.

" 7.—Another similar valve, but less dome-shaped than Fig. 5, and with a larger area of attachment.



Frank R. Leggatt, Del.

EXPLANATION OF PLATE VIII.

Cucullæa, *sp.*

Fig. 1.—Imperfect Right valve, possibly referable to *C. inflata,* Moore

,, 2.—Umbonal elevation and partial area of the same specimen.

Cucullæa semistriata, *Moore.*

,, 3.—Umbo, area, and teeth of the articulus.

Alectryonia Marshi, *J. Sby.*

,, 4.—An imperfect specimen exhibiting the strong subradiating costæ, and undulating or zig-zag front.

Pecten (?), *sp.*

,, 5.—A small valve provisionally referred to *Pecten* with strong costæ.

,, 6.—Another valve, probably the opposite to that represented in Fig. 5.

Radula duplicata, *J. de C. Sby.*

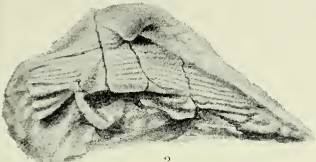
,, 7.—Portion of a valve, less the auricles.

,, 8.—The costæ, primary and secondary, much enlarged.

Pleurotomaria Greenoughensis, *Eth. fil.*

,, 9.—The shell seen in elevation.

,, 10.—The base.



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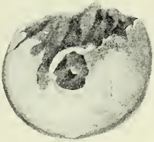

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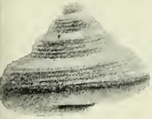

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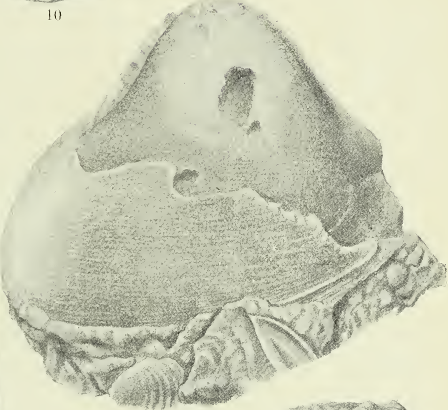

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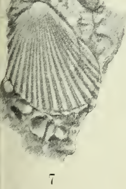

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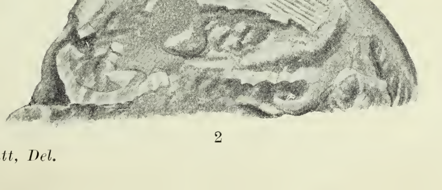

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Frank R. Leggatt, Del.

EXPLANATION OF PLATE IX.

PECTEN (?) CINCTUS, *J. Sby.*

Fig. 1.—Flat valve much exfoliated, with remains of the auricles.

OSTREA, *sp.*

,, 2.—Interior of an upper or flat valve exhibiting area above, test laminæ at the sides, and the adductor scar.

RHYNCHONELLA VARIABILIS, *Schlotheim.*

,, 3.—Umbo of the pedical valve, and the brachial valve with the fold occupied by three costæ.

,, 4.—Lateral view of the specimen represented in Fig. 3—× 3.

,, 5.—Pedicle valve of the specimen represented in Figs. 3 and 4 ; the sinus occupied by two costæ—× 3.

,, 6.—A second specimen, the fold of the brachial valve bearing two costæ —× 3.

DORSETENSIA CLARKEI, *Crick.*

,, 7.—A large example exhibiting the costæ and keel of the venter.

SPHÆROCERAS SEMIORNATUS. *Crick* (?).

,, 8.—Cast from a natural mould in limonite displaying a very imperfect specimen.

8

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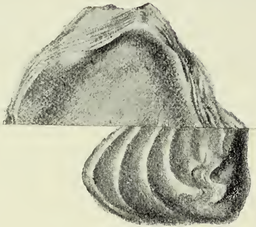

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Frank R. Leggatt, Del.

Plate IX.

Frank R. Leggatt, Del.

IV.—*Sthenurus Occidentalis (Glauert).*

BY

LUDWIG GLAUERT, F.G.S.

Field Geologist.

Introduction.

In the course of a construction of a pathway in the Mammoth Cave, Margaret River, 1904, the workmen found it necessary to break into a large boss of Stalagmitic material. As soon as the external layer had been removed, bones, mostly in a fragmentary condition, were encountered. Many of these were laid on one side, but, owing to the true significance of the discovery not being evident to those engaged upon the work, many valuable portions were doubtlessly destroyed or lost, while those to hand have suffered considerably from the rough usage to which they have been subjected.

Mr. E. A. LeSouef, the Director of the Zoological Gardens, collected numerous specimens, which he had conveyed to Perth, where, in due course he handed over the majority to the Secretary of the Caves Board of Western Australia, the authority controlling the cave where the bones were found. In November, 1908, Mr. LeSouef, made a further delivery of fossil remains, obtained with those previously handed over, including a lower jaw which he had recognised as belonging to *Sthenurus*, an extinct genus of the Macropodidæ not previously recorded from this State.

The Caves Board, aware of the great importance of the find, submitted the specimens for examination and description. The report, dated January 26th, 1909, was submitted to the Board at the meeting held on Friday, January 29th.

ORDER MARSUPIALIA.

Sub-order Diprotodontia.

Family Macropodidæ. Sub Family Macropodinæ.

Genus Sthenurus, *Owen* 1873.

Sthenurus (1) Owen Proc. Roy. Soc. London XXI., No. 141, p. 128—1873.

(1.) Synonomy *Fide*. Trouessart's "Catalogus Mammalium" Tom. II., 1900.

Owen Phil. Trans. Roy. Soc. London, CLXIV., pt. I., p. 265—1874.

Lydekker Cat. Foss. Mam. Brit. Mus. (N.H.) pt. V., p. 232—1887.

Lydekker Handb. Marsup. p. 253—1894.

DeVis. Proc. Lin. Soc. N.S.W., 2nd Series, Vol. X., p. 33—1895.

Protemnodon (partim) Owen Proc. Roy. Soc. London, XXI., No. 141, p. 128—1873.

Owen Phil. Trans. Roy. Soc. London, CLXIV. pt. I., p. 274—1874.

Procoptodon Owen Proc. Roy. Soc. London, XXI., No. 145, p. 387—1873.

Owen, Phil. Trans. Roy. Soc. London, CLXIV., pt. II., p. 786—1874.

Pachysiagon (n.n.) Owen Proc. Roy. Soc. London, XXI., No. 145, p. 386—1873.

Owen Phil. Trans. Roy. Soc. London, CLXIV., pt. II., p. 784—1874.

Macropus (partim) (1) Owen Mitchell's 3 Exped. East Austr., Vol. II., p. 359—1838.

Owen Descr. Cat. Mam. Aves. Roy. Coll. Sur. London, p. 325—1845.

Macropus (*Sthenurus*) *atlas* (type) Wellington Valley, N.S.W.

Sthenurus occidentalis, Glauert.

Sthenurus sp. nov. Glauert Proc. Geol. Soc. London, No. 881, p. 120—1909.

Quart. Journal Geol. Soc. London, Vol. LXV., p. 462—1909.

Sthenurus occidentalis sp. nov. Records W.A. Museum, Vol. I., pt. 1, p. 31, etc., 1910.

Prof. Owen's description of *Sthenurus atlas*, which is the type of the genus, is published in the Philosophical Transactions of the Royal Society of London, CLXIV, Part I., 1874, pp. 265-274, with figures (2) and is rather too lengthy to quote here, particularly as much abbreviated accounts of the generic characters are given by later authors.

Mr. R. Lydekker, the author of the Catalogue of the Fossils Mammalia in the British Museum (N.H.), suggests radical alter-

(1.) *See* also Owen " The Extinct Mammals of Australia " 1877, a work which contains the results of Prof. Owens' researches on the extinct Marsupials of Australia united in book form.

(2.) This description is repeated in Owen's " Extinct Mammals of Australia," 1877, pp. 416—424, etc.

ations in part V. of that work. He restricts the Genus of *Sthenurus* to one species only *S. atlas.* and places all the other species under *Macropus.* Further he states (1) "It will be shown in the sequel that all the upper jaws dsecribed by Owen under the name of *Sthenurus* and the lower ones as *Protemnodon,* indicate large Wallabies belonging to the present genus: (*Macropus*), although the genus *Sthenurus* as defined below, is a valid one."

On page 231 of the same volume we find the description of *Sthenurus.* "The fourth upper premolar develops a complete inner, and the lower one a corresponding outer lobe, so that the worn crown of these teeth present oval, flat surfaces, and have no secant edge. The true molars have no vertical enamel folds, and are short and wide: the longitudinal bridge connecting the ridges being very imperfect, and the anterior talon of the upper molars unconnected by such a bridge with the first ridge. The mandibular symphysis is not anchylosed, and the lower incisors are of the macropine type. The Genus connects *Macropus* with *Procoptodon.* This latter genus was described as follows (2) by Mr. Lydekker: "Genus *Procoptodon* (Owen). The mandibular symphysis is anchylosed in the adult, and the ramus of the mandible short and deep, the diastema being also short. The premolars resemble those of *Sthenurus* in structure, but the true molars are elongated and usually have their enamel thrown into a series of vertical folds. There are large palatal vacuities: and the lower incisors are subcylindrical."

There being a large stock of material in the Queensland Museum. the curator, Mr. C. W. DeVis, examined the specimens in that collection with a view of adopting the new classification. He found, however, that he could not separate *Sthenurus* and *Procoptodon* on account of the numerous intermediate-forms, and therefore wrote (3). "An amalgamation of *Procoptodon* with *Sthenurus* is demanded by their verisimilitude of tooth sculpture. and by the occurence of forms of transition between the two. Owen's reference of the maxilla of *Protemnodon anak* to *S. atlas* has been accounted for by Mr. Lydekker."

The enlarged Genus *Sthenurus* is defined by Mr. deVis in these terms:—

> "Lower permanent premolar with an obliquely disrupted lobe forming the posterior moiety of the outer side, the cleft occupied by sinuous and papillary folds. Upper permanent premolar with a broad ledge on the inner side its cavity traversed by erect folds. Molars short, with ascending, tapering, spreading folds incumbent on their surfaces; posterior, basal, margins tumid, but rarely forming distinct talons, mandibular symphysis generally anchylosed; lower incisors generally small, laterally compressed and much less incumbent than in other Macropods. A vascular foramen on the outer side of the mandible beneath one of the posterior molars. Posterior orifice of dental canal generally above the level of the teeth. Palate with large vacuities."

(1.) *op.* cit., p. 207.
(2.) *op.* cit., p. 233.
(3.) Proc. Lin. Soc. N.S.W., 2nd series, Vol. X., p. 88—1895.

As the specimen under consideration possesses characteristics associated by Mr. R. Lydekker with *Procoptodon* and *Sthenurus* as distinctive features and also disagrees with both of them in several important points (×) it has been considered advisable to adopt the name of *Sthenurus* in the wider sense suggested by Mr. C. W. deVis.

Description.

The specimen consists of the major portion of the left mandibular ramus, embracing the incisor, the diastema, all the cheek teeth and the lower part of the coronoid united in the position of nature to the right ramus which is perfect up to and including the third cheek tooth (m2) (1). The state of the teeth show that the last molar (m4) has been in use for some time before the death of the animal, the individual would therefore be classed as *aged* by Mr. Oldfield Thomas (2) and as *adult* by Mr. C. W. deVis (3). All the milk teeth have been shed, and of the permanent dentition every member shows signs of wear.

It is possible to take the following measurements, chiefly on the left side.

Incisor (*i*) length from base of enamel to the extremity of the worn crown 22 m/m: length of cutting edge of crown 13 (1) thickness of crown 6·5 ; vertical diameter at base of enamel 11 ; transverse diameter 7.

Diastema.—Length, from posterior base of enamel of incisor to anterior edge of socket of premolar (p4) 22·5.

Cheek teeth.—Length of entire series, *in situ*, from anterior edge of p4 to hind edge of m4 61.

Premolar (p4) antero-posterior dimension 17, summit of crown 12·5, greatest width of anterior moiety 7, of posterior 9.

First Molar (m1) (5) length 10·5, width fore lobe (6) 8·5, hind lobe 8·5.

Second Molar (m2) length 11·5, width fore lobe 8·5, hind lobe 9·5.

Third Molar (m3) length 12·5, width, fore lobe 10, hind lobe 10.

Fourth Molar (m4) length, 11·5, width, fore lobe 9·5, hind lobe 9.

The Mandible.—Length of jaw from the tip of the incisor to the hind margin of the coronoid 160 : greatest depth in front of

(× .) This specimen has the anchylosed symphysis, the short and deep ramus, the short diastema and the vertical folds in the enamel of the molars of *Procoptodon* associated with the short and wide molars of *Sthenurus*, the longitudinal links are but faint.

(1.) At the time of the preparation of this Report, I was permitted by the Director of the W. A. Museum to examine several boxes of specimens presented to that Institution by the Caves Board, and I had the good fortune to find the remainder of the right ramus so that the specimen is practically a complete lower jaw. This description simply deals with those portions submitted by the Caves Board in December, 1908.

(2.) Catalogue of Marsupialia and Monotremata in the collection of the British Museum (NH.) p. 7, 1888.

(3.) " A Review of the Fossil Jaws of the Macropodidæ in the Queensland Museum." Proc. Linn. Soc. N.S.W., 2nd series, Vol. X., p. 79—1895.

(4.) As all the measurements are given in millimeters it is proposed to omit the m.m. in this section.

(5.) This corresponds to the d4 of Professor Owen. The m1 of this authority agrees with the m2 of later writers.

(6.) In this list of measurements, the width of the lobes of the molars is the extent of the cutting edges of the lobes.

p4—34, greatest depth at m4, 35: depth behind p4, 31. Thickness under p4—15, behind m3—18, anterior dental (vascular) (1) foramen $7\frac{1}{2}$–8, below the diastemal border and slightly in advance of p4. A second, smaller foramen 15 below the base of the posterior lobe of m1.

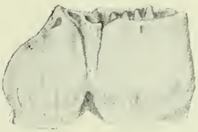
The Teeth.

The Incisors. (*i*).

These teeth are shorter, but vertically longer, than in Macropus, they gradually taper from the base to the extremity and have an outline very similar to the corresponding teeth of *S. atlas*, as figured by Owen (2) though their working surface is relatively longer, a feature which is no doubt due to the greater age of the individual, the inner surfaces of the tooth are covered with enamel, whilst even on the former there is an inverted V-shaped sinus caused by the encroachment of the radical cement.

At the socket the teeth have an oval or elliptical section, and an ovate, almost lozenge-shaped one at the base of the enamel.

Fig. 1.



L.G., del. p4 × 2.

The left lower premolar (p4) outer aspect, twice the natural size

Fig. 2.

L.G., del. p4 × 2.

The same, seen from above, twice the natural size.

The Premolar (p4). Figs. 1 and 2.

This tooth is elongately oval in horizontal section, possessing a marked constriction at a point 7 m/m from the anterior basal edge, chiefly on the outer aspect, which almost divides the tooth into a fore and a hind lobe: the constriction passes upwards and backwards to the cleft which proceeds obliquely along the crown of this tooth so that the lobe forming the anterior portion of the outer surface of the crown occupies the whole of the inner face. At the anterior extremity of this cleft there is a notch in the crown of the tooth. The posterior part of the crown is shorter than the

(×.) This specimen has the anchylosed symphysis, the short and deep ramus, the short diastema and the vertical folds in the enamel of the molars of *Procoptodon* associated with the short and wide molars of *Sthenurus*, the longitudinal links are but faint.

(1.) Later authorities term this the mental foramen.

(2.) Phil. Trans. Royal Soc. 1874, Plate XXII., figs. 5 and 6, and Extinct Mammals of Australia, Plate LXXXII., figs. 5 and 6.

crown of the succeeding molar, it was evidently used for crushing or pounding as it has a broad working surface with complex transverse ridging between the inner and the outer edges. Of the complex folds or ridges one is of much greater size and prominence than the rest.

The outer and inner faces of the fore part of the tooth each possess three more or less distinct folds which pass upwards from the prebasal ridge : the apices of the first and second form the well-marked anterior prominence of the tooth, the third reaches up to the ridge that passes backwards from the prominence to the hind part of the crown. This ridge after having been traversed by the notch of the point of the constriction passes uninterruptedly to the intero-posterior angle, here it is broken by a distinct vertical fold, then it sweeps round to form the curved trenchant edge of the postero-external lobe and to join the fore and aft ridge at the point of constriction. A faint prebasal ridge can be traced on the fore, inner and outer aspects of the tooth but is entirely absent from the hind face, which is perfectly smooth and plain from side to side, and base to crown.

Fig. 3.

L. D., del. m2 × 2.
The second right lower molar (m2) seen from above, twice the natural size.

The Molars (m1—m4). Fig. 3.

These teeth are short and wide, the lobes are thin and almost straight, being slightly convex backwards. The crests of the lobes are slightly concave, angles sharp, forming a sharp point on the inner edge, but on the outer one resembling a somewhat thickened protuberance from which a marginal fold proceeds downwards and forwards almost closing—in the case of the one from the hind lobe—the mid-valley, the fold from the fore lobe fringing the outer edge of the fold that forms the anterior ledge, or talon, of the lobe. Similar marginal folds, but branching are to be seen on the anterior surface of the inner angle of the fore lobe, and are represented by a simple marginal fold on the anterior surface of the inner angle of the hind lobe. External incumbent fold on the fore lobe large and

prominent sweeping round to form a sharp ridge along the anterior ledge or talon of the tooth. The second fold is very short and almost rudimentary, the third slightly less prominent than the first, branching, the branches reaching to the base of the anterior ridge, three or four additional folds are more or less indistinct. In a worn tooth most of these folds are very difficult to distinguish.

Several vertical folds on the hind surface of the fore lobe, only two of which can be seen distinctly, the outer one forming the longitudinal link and the second giving rise to a subsidiary link. A third very subordinate vertical fold forms a faint line reaching to the inner angle of the hind lobe. Two or three additional markings are present, evidently corresponding to the insignificant folds on the fore surface of the hind lobe. Hind surface of the hind lobe ornamented with numerous about nine, rudimentary vertical folds which pass down to the slight post basal swelling that can hardly be termed a ridge.

The Ramus. (Plates X., XI., XII.)

The lower jaw is strong and powerful, it differs considerably from that of *Macropus*, firstly it is much more solidly built, which, together with the shape and size of the teeth, suggests that the animal's food consisted of hard vegetable matter ; secondly, the diastema being short and straight and not long and curved, the contour of the upper border of the ramus differs to a marked extent from that of *Macropus*.

As in Owen's figure of *S.atlas* (1) we find a large for a men present on the outer side of the mandible below the diastema and slightly in front of p4, as well as a second smaller one which is placed under m1 instead of beneath one of the posterior molars. The rear portion of our specimen shows the fenestral vacuity in the form of a pouch having its opening slightly below the level of the alveolar platform, it communicates with a pouch on the inner surface of the jaw by means of a fenestral foramen. The posterior opening of the dental canal is also distinctly to be seen in the pouch.

The post-alveolar platform has a sharp inner border and a most distinct angle. The outer face of the ramus bears a platform under and round the base of p4 and a short groove commencing 15 m/m below the crown of p4 and extending as far as the hind edge of m1.

Immediately below this channel the outer surface of the ramus swells considerably so that the section is fairly convex in a vertical direction though almost straight horizontally.

On the inner face of the ramus the ramus thins rapidly below a well-marked ridge that runs obtusely along the ramus, connecting the posterior extremity of the alveolar platform with the lower end of the symphysis. The symphysis is anchylosed and large in extent ; above it there is the postsymphysial depression which

(1.) Phil. Trans. Royal Soc. London, 1874, Plate XXII., fig. 5.

is present in both rami and consists of a channel communicating with a foramen (?)

Little of the coronoid process is to be seen, still it is evident that the anterior border of the ascending process ran at right angles to the line of the molars.

The lower border of the mandibles shows a distinct upward arch rising abruptly at the posterior end of the symphysis.

Compared with *S. atlas*, as figured by Owen, the ramus is seen to be considerably deeper and thicker in proportion to its longitudinal extent, the diastema is markedly shorter, $12\frac{1}{2}$ m/m—and the incisors much more inclined.

Sthenurus occidentalis.

Specific Characters.—Longitudinal links continuous, with the outermost of the incumbent folds, low, but distinct; a second link, lower and very indistinct in a worn tooth, present in the mid-valley of all the molars. Posterior basal ridge absent in m1 and but faintly in the other molars.

Mandible thick, symphysis anchylosed. Incisor inclined, posterior dental foramen below the lower of the teeth, level with the alveolar groove. Anterior edge of the coronoid process rising at right angles to the line of the teeth ; under surface of the mandible arched upwards. Diastema short. Ramus thinner than in *S. oreas* (DeVis), and deeper than in *S. atlas.* (Owen).

Note.—The subsequent examination of several additional specimens shows that " the external incumbent fold on the fore lobe which sweeps round to form the sharp ridge along the anterior talon of the tooth " is ornamented with two or three vertical folds on its outer aspect. (1.)

Differences and Resemblances.

S. goliah, Owen. *S. rapha*, Owen, and *S. pusio*, Owen.

These forms are much larger in size and have differently shaped rami and teeth. The ornamentation is also of a different pattern.

S. pales. Owen.

This form is much larger in size but resembles *S. occidentalis* in the arrangement of the incumbent folds on the anterior aspect of the fore lobes of the molars and in the sculpturing of the posterior surfaces of both the fore and hind lobes.

S. otuel. Owen.

This species is of much greater size than the specimen under review, and has teeth which are differently shaped but which bear ornamentations very similar to those found on *S. occidentalis.*

(1.) *Vide* also sequel.

S. oreas. DeVis.

Our form has the same general outline as this species and the same depth of ramus as well as an anchylosed symphysis. On the other hand, the teeth are of different dimensions, as will be seen from the table below. The ramus is also considerably thinner than that of *S. oreas*, so that there can be no hesitation in looking upon our form as distinct from this Queensland species—we must bear in mind that ours is the jaw of an " aged " or adult animal in whose skeleton no further developments are to be expected.

	S. oreas (†).	*S. occidentalis.*
Cheek series	..62·2 m/m ..	60–61 over all
m1–m4	..58	45 ,,
m1–m3	..41·5	32–33 ,,
p4	..11·9	12·5 (17) ,,
m3 (length of) ..	..14·6	12·5 ,,
m3 (width of) ..	..12·1–13·2 ..	10 ,,
Thickness of mandible	..22·5–25·8 ..	15 x 17 or 18
Anterior depth of mandible	34·2	34
Posterior depth of mandible	35·5	35

S. atlas. Owen.

This species (according to DeVis, *loc. cit.*) is distinguished from *S. oreas* by having a much more slender ramus and by the fact that the symphysis is not anchylosed. In shape too, the ramus is flat exteriorly, increasing in depth posteriorly. Lower contour lines straight or arched upwards.

Against this, our form is thick, the exterior surface slightly convex longitudinally (horizontally), much more so vertically. Lower contour line arched upwards. Symphysis anchylosed.

Owen's figure of *S. atlas* (1) shows a ramus which differs from *S. occidentalis* in one or two other points; for instance, it has a longer diastema and shows very little if any trace of the inverted ridge or projection which is so evident on the inner side of the ramus of our form of *Sthenurus*.

As regards measurements we find the following relations :—

	S. atlas (2).	*S. occidentalis.*
Cheek series	55·8–58·6	60–61 over all
m1–m3	30·1–31·6	32–33 ,,
p4	12·1 x 6·8–12·8 x 7	12·5 x 6 (17 x 7 x 9) over all
m3 (width of) ..	8·9–10·5	10 over all
Thickness of mandible	14·8–15·6	15–17 or 18
Anterior depth of mandible	26·1–28·5	34
Posterior depth of mandible	29–32·7	35

(†.) *Op. cit.*, p. 96.
(1.) Owen. Phil. Trans., 1874, pl. XXII., figs. 5, 6, 7 and 8.
(2.) De Vis., op. cit. p. 98.

There is evidently a close relationship between our form and these last two species.

Since the above description was written I was engaged by the Western Australian Museum Committee and the Caves Board of W.A. to undertake further explorations in the Mammoth Cave. Amongst 2,000 specimens, several mandibular rami of *S. occidentalis* were obtained which, upon examination, confirmed the description and measurements given in my report to the Caves Board. All the specimens obtained were presented to the Western Australian Museum by the Board in March 1909.

Note.—Amongst the specimens transferred to the Department by the Western Australian Museum authorities in 1908 were four large fragments of rock with a label "Gypsum from Cliffy Head, Dongara."

Upon these being examined by Mr. E. S. Simpson and myself at that time, traces of animals remains were observed, and the material in which the bones were embedded identified as Limestone and Stalagmite, not Gypsum. The specimens were therefore laid on one side for further examination. Subsequently I was instructed to examine the material, and as a result I have been able to extract a portion of the left lower jaw of a *Sthenurus*. The state of preservation of the fossil, the nature of the matrix, and the numerous inclusions of fragments of charred wood, twigs, and branches of trees, snail shells, together with the casts of leaves of Eucalypts, and the fact that the fossil is a *Sthenurus occidentalis*, cause me to state with every confidence that the specimens must have come from the Mammoth Cave, Margaret River, S.W.

Most likely they are a portion of the collection made by the Director of the Museum, Mr. B. H. Woodward, during his visit to the Cave in August, 1905. (1).

The specimen [**10087**] is somewhat damaged, but still it bears the socket and root of the incisor, the premolar p4 (2) and the first, together with the anterior half of the second molar m1 and m2.

MEASUREMENTS.

The following measurements are possible :—

The Teeth.—p4 length (crown 12·5 m/m)	14·5 m/m over all	
	Width of fore lobe cutting edge	7·5
	Width of hind lobe cutting edge	9
	m1. length of crown ..	10·5
	Width of fore lobe cutting edge	8·5
	Width of hind lobe cutting edge	9
	m2. length	
	Width of fore lobe, cutting edge	9

(1.) Records of the W.A. Museum, Vol. I., part 1, p. 10—1910.

(2.) The dental formula in use in the British Museum (N.H.) is adopted, the manner in which it differs from that proposed by Prof. Owen has already been referred to.

The Mandible—

Depth of mandible in front of p4 about ..	.. 36 m/m
Depth of mandible behind p4 ..	.. 31·5
Thickness under p4	.. 15

The anterior dental foramen (1), $3\frac{1}{2}$m/m in diameter, is situated about 8m/m below the diastemal edge, and slightly in advance of p4. The length of the diastema, which is imperfect, would be about 22m/m.

Description.—The premolar (p4) differs somewhat from the corresponding tooth of the type of the species; the most important feature is the presence of a small cusp or tubercle on the inner half of the anterior aspect of the tooth. The suggestion of a similar process is seen on the premolars of some of the mandibles in the W.A. Museum Collection.

The foldings of the complex transverse ridging on the broad working surfaces, which occupies the posterior portion of the crown, is rather more complicated, perhaps due to the state of wear of the tooth, but more likely an individual feature, for the examination of all the premolars of *S. occidentalis* which I have been able to examine shows slight variations in the arrangement of these folds. The vertical fold in the enamel at the intero-posterior angle is so worn that all but the base of the conical pit has been removed.

The outer aspect of the tooth is very similar to that of the type, but the inner one bears traces of two or three rudimentary vertical folds, just beneath the posterior portion of the crown, which are not to be seen on the type.

The Molars.—The first molar (m1) is very much worn, the summits of the outer extremity of both fore and hind lobe are so worn that in each case the dentine is exposed. The ornamentation of the teeth is as in the type, with the addition that the vertical folds on the hind surface of the hind lobe of m1 rise from an arched post-basal ridge which, though slight, is quite distinct (†), and that though this animal was considerably older than the type at the time it met its death, the vertical folds on the outer aspect of the " external incumbent fold on the fore lobe, which sweeps round to form a sharp ridge along the anterior talon of the tooth " can be seen with the aid of a lens. These folds are not very prominent in some specimens, and seem to be soon worn away—they are exceptionally distinct on the second molar of the specimen in the departmental collection, and have been recognised on the type specimen (2) since it was described.

The Ramus is very strong, that portion which is preserved has the same thickness as the type, but the depth is somewhat greater, both before and behind p4 due, no doubt, to the greater age of the animal (3). The exposed root of the incisor enables

(†) In my examination of the type specimen I could find no trace of any post-basal ridge on *m*1.

(1.) Prof. Flower has designated this foramen the mental foramen, *see* Osteology of the Mammalia.

(2.) *See ante* p.... and Records of the W.A. Museum, Vol. I., part 1, p. 36—1910.

(3.) This increase in depth of the ramus as the animal ages is a common feature with the Macropodidæ.

one to guess the length of the diastema which, had it been perfect, would have had the same extent as in the type. The state of the fractured inner surface at the root of the incisor proves that the symphysis was anchylosed.

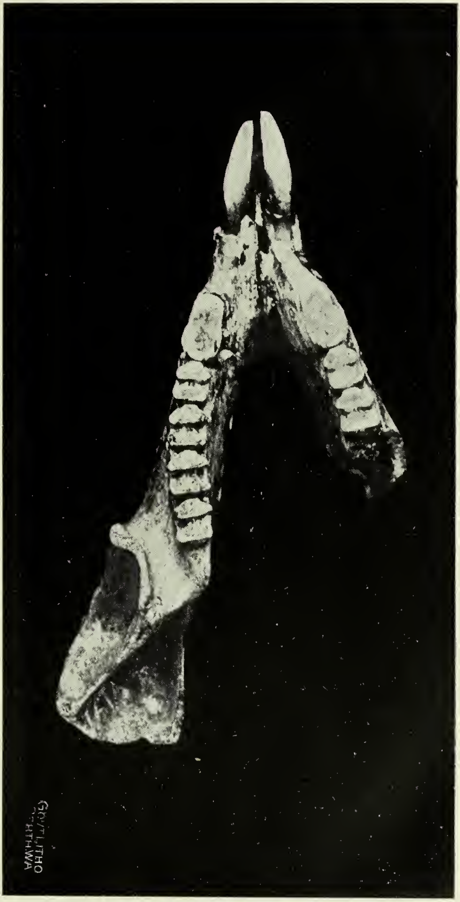
The discovery of this specimen is interesting, as it helps to prove that the features seen and recognised upon the type of the species as points of difference are not merely individual variations, but characteristics of a group of animals—a distinct species of *Sthenurus*. The presence of the vertical folds on the outer aspect of the external incumbent fold on the anterior lobe of every molar of this species yet examined is an important additional feature peculiar to *S. occidentalis*.

EXPLANATION OF PLATES.

Plate X.—The united rami seen from above.

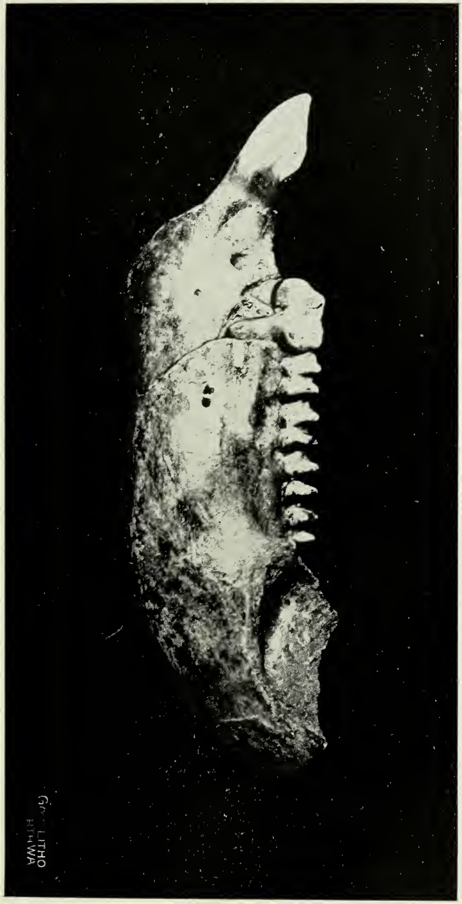
Plate XI.—Exterior aspect of left ramus.

Plate XII.—Interior aspect of same.



Sthenurus occidentalis (Glauert) × ¾.

The united rami seen from above.



Sthenurus occidentalis (Glauert) × ¾.

Exterior aspect of left ramus.

Sthenurus occidentalis (Glauert) × $^3/_4$.

Interior aspect of left ramus.

V.—A List of Western Australian Fossils (systematically arranged),

BY

LUDWIG GLAUERT, F.G.S.,

Field Geologist.

General Introduction.

This list is an attempt to catalogue all the Western Australian Fossils that have been collected in the State up to the end of 1908.

Whilst every care has been taken to make it as complete as possible, it is felt to be far from perfect owing to the vagueness of some of the localities, the uncertainty of various names, and the disappearance of many of the specimens.

Although Western Australian Palæontology is still in its infancy several attempts have been made to catalogue the forms then known.

In 1870 Chas. Moore compiled a list of the Mesozoic Fossils (*vide* Q. J. G. S., Vol. XXVI., 1870, p. 232), which was the authority for Mr. Etheridge's "Catalogue of Australian Fossils" of 1878—as far as the Western Australian Fauna was concerned. Some five years later W. H. Hudleston gave a list of the Palæozoic Fossils that had been submitted to him for examination and description (*vide* Q. J. G. S., Vol. XXXIX., 1883, p. 590). The next list compiled was that published in the Annual General Report for 1890, by Mr. H. Page Woodward, at that time Government Geologist. This was the first attempt to classify all the Western Australian Fossils, and is the most comprehensive Catalogue that is known to this Department at the present time. In order to show the advances made in Western Australian Palæontology since that date, all the species then recorded are prefixed with the letter "W" in the following pages. Since 1891, untabulated lists have appeared in the following Government publications and in the presidential address, Section "C," Geology, at the Adelaide meeting of the Australasian Association for the Advancement of Science, 1907, all over the signature of Mr. A. Gibb Maitland, the present Government Geologist of this State. Although up to date, they do not claim to be complete or systematically arranged, and so do not fill the place that this present catalogue is intended to occupy.

Bulletin No. 4.—The Mineral Wealth of Western Australia, Chapter I, 1900.

Bulletin No. 26, part 7.—Recent Advances in the Knowledge of the Geology of Western Australia, 1907.

Year Book.—Western Australian Year Book (article "Salient Geological Features"), from Bulletin No. 4, 1902–4.

It was the original intention to include all the Western Australian Fossils in this present list, but more careful investigation of the specimens and their labels show that almost all the Cainozoic examples were badly preserved casts, which did not permit an exact determination. As it would be useless to include such very doubtful records, it was thought more advisable to confine the list to the Palæozoic and Mesozoic Times only, and to leave the Cainozoic and more recent examples till better preserved specimens came to hand, or circumstances permitted more time being spent upon them, so that some definite result might be obtained.

Again, the known fossil flora of Western Australia is so small and insignificant that it was considered the wiser plan to confine it to a separate article.

The plan adopted is to a great extent similar to that of Mr. Etheridge: the animal remains are in zoological order (after Zittel), and occupy the first longitudinal subdivision; in the second subdivision the localities are placed in geographical sequence from North to South; the third column is reserved for references to publications, which are indicated by letters of the alphabet, *see* page 73 (when the letters represent works containing figures or illustrations of the species they are printed in capitals); then follows the subdivision containing the names of the Museums known to contain Western Australian Fossils, here the presence of a species is recorded by means of a ×. As this list is designed chiefly for use in this State it was considered an advantage to distinguish species represented in the Geological Gallery of the Western Australian Museum by printing the names in a **heavier type**. Species exhibited in other Museums, and not in the National Collection, have their names printed in ordinary type, whilst the name of specimens that are recorded but cannot be traced to any collection are printed in *italics*.

In compiling this work the first Bulletin issued by the Department, The Bibliography of the Geology of Western Australia, by A. Gibb Maitland, 1898, was freely used, and all its references consulted wherever possible.

For articles of later date, manuscript notes made by the Government Geologist were found of great assistance. The Assistant Keeper of the Geological Department of the British Museum (Natural History), the Assistant Secretary of the Geological Society of London; the Directors of the Western Australian Museum; the Australian Museum, Sydney; the National Museum, Mel

bourne ; the Public Library, Museum, and Art Gallery, Adelaide ; the Museum of the Geological Survey of New South Wales, Sydney ; the Curator of the Bath Museum (England), and the Department of Agriculture and Technical Instruction, Dublin, have given useful and valuable information which is gratefully acknowledged.

The task has proved most interesting and instructive to me, and has suggested many problems and possibilities, so that it is hoped that in the near future it may be possible to amplify the present list.

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(*c.*) **Etheridge, R.** "Catalogue of Australian Fossils."—1878.

(*d.*) **Hudleston, W. H.** "On a Collection of Fossils and of Rock specimens from West Australia, North of the Gascoyne River." Quart. Journ. Geol. Soc., Vol. XXXIX.—1883.

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(*h.*) **Etheridge, R.** "On Permo-Carboniferous Fossils from the Irwin River Coalfield, Western Australia." Appendix C. to the Annual Report of the Department of Mines, N.S. Wales, for 1889—1890.

(*i.*) **Foord, A. H., Nicholson, H. A., Hinde, Geo. J.** "Notes on the Palæontology of Western Australia" (two parts). Geol. Mag., Dec. III., Vol. VII.—1890.

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(*l.*) **Crick, G. C.** "On a Collection of Jurassic Cephalopoda from Western Australia." Geol. Mag., Dec. IV., Vol. I.—1894.

(*m.*) **Howchin, W.** "Carboniferous Foraminifera of Western Australia, with descriptions of new species." Trans. Royal Soc., South Austr., Vol. XIX., part 2—1895.

(*n.*) **Maitland, A. Gibb.** "Annual Progress Reports of the Geological Survey for the years 1897-1908."

(*o.*) **Maitland, A. Gibb.** "The Mineral Wealth of Western Australia" (Bulletin 4)—1900.

(*p.*) **Etheridge, R.** "Palæontological Contributions to the Geology of Western Australia I." (Bulletin 10)—1903.

(*q.*) **Chapman, F.** (1.) "Foraminifera and Ostracoda from the Jurassic Strata near Geraldton, Western Australia."

(2.) "On a Collection of Palæozoic and Mesozoic Fossils from Western Australia." Proc. Royal Soc., Vict., Vol. XVI.—1904.

(*r.*) **Maitland, A. Gibb.** "Recent Advances in the Knowledge of the Geology of Western Australia." Austr. Assoc. Adv. Sci. (Adelaide). 1907, and Bulletin No. 26.—1907.

(*s.*) **Etheridge, R. Chapman, F., Howchin, W.** "Palæontological Contributions to the Geology of Western Australia II." Bulletin 27, 1907.

(*t.*) **Hinde, G. J., Newell, Arber E. A., Etheridge, R., Glauert, L.** "Palæontological Contributions to the Geology of Western Australia." III. (Bulletin 36)—1910.

(*u.*) **Maitland, A. Gibb.** "Geological Investigations in the Country lying between 21° 30′ and 25° 30′ S. Lat., and 118° 30′ E. Long., embracing parts of the Gascoyne, Ashburton, and West Pilbara Goldfields" (Bulletin 33)—1909.

(*v.*) **Campbell, W. D.** The Irwin River Coalfield, Bulletin 38.

NOTE.—Figured specimens are indicated by capital letters in the column of References throughout the Tables.

PART I.

PALÆOZOIC FOSSILS.

The greater portion of Western Australia consists of Igneous or Metamorphic rocks of great antiquity, but in the "Kimberleys," the "North-West" to the "Gascoyne," large stretches of country consist of Palæozoic Rocks which have been recognised by most competent authorities as being chiefly of Carboniferous Age. A strip, running down between the Darling Ranges and the coast, is met with in the Victoria District, and may possibly be exposed at Bullsbrook, near Midland Junction, and further South along the

base of the Darling Ranges, but of this no definite Palæontologica evidence has yet been discovered. Still further South the Collie Coal Basin is the extreme outpost of the beds of this coal-bearing age so far as is yet known.

As regards Devonian Rocks, there is but very scanty information. Hardman (1) recognised Devonian strata in the Kimberley area and obtained fossils which are true Devonian types

In 1906, Mr. H. P. Woodward, in the course of an extended trip in the West Kimberley District, collected a number of specimens from the Barker Gorge in the Napier Range, which London authorities have classified as of undoubted Devonian age.

Some of the older writers, Hudleston, etc., determined possible Devonian forms from the "Gascoyne" and the "Irwin" localities, which the latter researches of this Department have failed to verify.

Rocks of greater antiquity are present in Western Australia, for Hardman obtained undoubted Cambrian fossils from Kimberley, but our knowledge is very restricted as it is not even definitely known where Hardman collected his specimens. It is also supposed that the Stirling Ranges in the extreme South of the State are Silurian and, according to Hardman, that Lower Silurian, or Cambro-Silurian strata, are exposed in the country he examined in the North. It is needless to enter more fully into the matter here as all information can be obtained from Bulletin 26, part 7, of 1907, where the Government Geologist goes into the Geology of the State in detail.

The lithological character of the Palæozoic rocks is not striking, the Carboniferous representations are mainly grey crystalline limestone with occasional ironstained areas, but associated with these are carbonaceous and micaceous shales, sandstones and conglomerates, as well as Glacial beds and series of volcanic lavas and ashes. The Nullagine Beds may be either Cambrian or Devonian: they are not Carboniferous. The Devonian Beds are mostly grey limestones, whilst the older Palæozoic strata consist chiefly of more or less altered sedimentary rocks and crystalline limestones. For further information in this connection reference may be made to the publication of this Department, to which attention has just been drawn.

In the following portion of the list the pages have been divided into four main columns, as explained in the Introduction.

Locality.—Roughly speaking there are four chief districts, Kimberley, Gascoyne, Irwin and Collie. Of these, the second is subdivided into the Valleys of the Lyons, Wyndham, Gascoyne,

(1.) Hardman: "Report on the Geology of the Kimberley District" (two reports), dated 1884 and 1885.

and Wooramel Rivers ; whilst the third is split up into Irwin River Coal seam and Mingenew.

It has been thought advisable to consider Mingenew as one of the more important sections, as it is chiefly there that fossils homotaxial with the Permo-Carboniferous of the Eastern States have been obtained. (1.)

(1.) *Vide* G.S., W.A., Bulletin No. 27, page 19.

PALEOZOIC.

Cambrian.

	Genus and Species.	Locality.				Reference.	Exhibited.					
		Kimberley.					Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Sub-Kingdom Mollusca. Class Gastropoda. Sub-Class Euthyneura. Order Opisthobranchia. Sub-Order Conularida.											
W	**Salterella Hardmani** (Eth. fil.)	×	..	..	..	I.o.r. ..	×	×	..	..	×	..
	Sub-Kingdom Arthropoda Class Crustacea. Sub-Class Trilobita. Order Opisthoparia.											
W	Olenellus (?) Forresti (Eth. fil.)	×	..	..	..	I.o.r. ..	..	..	..	..	×	..

PALÆOZOIC—*continued*.

DEVONIAN.

	Genus and Species.	Locality.				Reference.		Exhibited.					
		Kimberley.	Barker Gorge, Napier Range.	Gascoyne River.				Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Sub-Kingdom COELENTERATA. Sub-Branch Cnidaria. Class Hydrozoa. Stromatoporoidea.												
	Actinostroma clathratum (Nich.)	×	..	..	..	I.o.	..	..	..	..	..	×	..
(?)	Stromatoporella Eifeliensis (Nich.)	×	..	×	..	I.o.	..	..	..	..	..	×	..
	Class Anthozoa. Sub-class Tetracoralla.												
(?)	Cyathophyllum depressum (Hinde)	×	..	×	..	I.o.	..	..	..	..	..	×	..
	,, **virgatum** (Hinde)	×	..	×	..	I.o.	..	×	..	..	..	×	..
(?)	**Phillipsastræa (Smithia) sp.**	..	×	..	..	t.	..	×	..	..	..	..	..
	Sub-Class Hexacoralla. Order Madreporaria. Sub-Order Tabulata.												
	Aulopora repens (Knorr & Walch)	×	..	..	..	I.o.	..	..	..	..	..	×	..
	Favosites Goldfussi (Edw. & Haime) (1)	×	..	×	..	..	..	×	..	..	..	..	..
	Pachypora tumida (Hinde)	×	..	..	..	I.o.	..	..	..	..	..	×	..
	,, **sp.**	..	×	..	..	t.	..	×	..	..	..	..	..
(?)	**Syringopora reticulata** *var.* **patula** (Hinde)	..	..	×	..	..	..	×	..	..	..	×	..

	Sub-Kingdom ECHINODERMATA. Sub-Branch Pelmatozoa. Class Crinoidea.											
	Stems and arms of Crinoids	×	..	×	..	i.	×	..	..	..	..	..
	Sub-Kingdom VERMES. Sub-Order Tubicola (Sedentaria.)											
(?)	*Spirorbis omphalodes* (Goldf.)	×	..	×	..	i.o.	..	..	..	..	..	..
	Sub-Kingdom MOLLUSCOIDEA. Class Brachiopoda. Order Protremata.											
	Productus *sp.*	×	..	..	..	..	×	..	..	..	..	..
	Order Telotremata.											
W	**Atrypa reticularis** (Linn.[1])	×	..	..	..	I.o.r.	×	..	..	..	×	..
	Rhynchonella cuboides (J. de C. Sowerby)	×	..	..	..	I.o.	×	..	..	..	×	..
W	,, **(Hypothyris) pugnus** (Martin)	×	..	..	..	I.o.r.	×	..	..	..	×	..
	,, **(Uncinulus)** *c.f.* **Timorensis** (Beyr.)	..	×	..	..	r.	×	..	..	..	..	..
	Spirifera Musakheylensis *var.* **Australis** (Foord)	×	..	..	..	..	×	..	..	..	..	..
(?)	,, *c.f.* Verneuili (Murch)	×	..	..	..	..	..	..	..	..	×	..
	,, sp.	×	..	..	..	I.o.r.	..	..	..	..	×	..
	Sub-Kingdom MOLLUSCA. Class Pelecypoda. Order Prionodesmacea.											
(?)	**Aviculopecten limæformis** (Morris) (2)	..	..	..	..	..	×	..	..	..	..	..
	,, **multiradiatus** (Eth. Sen.) (3)	..	..	..	..	..	×	..	..	..	..	..

(1.) Favosites gothlandica (Lamarck) *fide* Eth. fil Geol. and Pal., Queensland, p. 50. (2.) In a list of Fossils identified by the British Museum authorities and returned to Perth, 11th March, 1892, this shell is reported from Dandaraga, near Gingin. (3.) In the list referred to in the above foot-note an example of this species is reported from the South Coast, near Eucla.

PAL EOZOIC—*continued.*

DEVONIAN—*continued.*

	Genus and Species.	Locality.				Reference.		Exhibited.					
		Kimberley.	Barker Gorge, Napier Range.	Gascoyne River.				Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Class Gastropoda. Sub-Class Streptoneura. Order Aspidobranchia. Sub-Order Rhipidoglossa.												
	Euomphalus sp.	..	×	..	..	..	..	×	..	..	..	..	..
	Loxonema sp.	..	×	..	..	..	..	×	..	..	..	..	..
	Class Cephalopoda. Sub-Class Tetrabranchia. Order Nautiloidea. Sub-Order Orthochoanites.												
	Goniatites (Brancoceras) *c.f.* **rotatorius** (De Kon.)	×	..	..	..	..	..	×	..	..	..	..	..
W	,, **sp.**	×	×	..	..	I.o.r.	..	×	..	..	..	..	..
W	*Orthoceros spp*	×	..	..	..	I.o.r.	..	..	..	..	..	..	..
	Sub-Kingdom ARTHROPODA. Class Crustacea. Sub-Class Trilobita. Order Opisthoparia.												
	Proetus *sp. nov.*	..	×	..	..	t.	..	×	..	..	..	..	..

NOTE.—A fragment of bone of a coccostean fish was found associated with these Barker Gorge fossils, but it was too fragmentary to permit Dr. A. Smith-Woodward, F.R.S., to whom the specimen was submitted, to say more than that it belonged to a Coccostean fish, probably a new species allied to Coccosteus, and a new record for Australia.

PALÆOZOIC—*continued.*

CARBONIFEROUS.

	Genus and Species.	Locality: Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.	Reference.	Exhibited: Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Sub-Kingdom PROTOZOA. Class Rhizopoda. Order Foraminifera. Sub-Order Porcellanea.																		
*	Cornuspira Schlumbergi (Howchin)	..	..	..	..	..	..	..	×	×	..	..	k.M. ..	..	..	..	..	..	..
*	**Nubecularia Stephensi** (Howchin)	..	..	..	..	..	..	..	×	×	..	..	k.M.r.S.v.	×	×	..	..	..	..
	Sub-Order Vitro-Calcarea.																		
	Bulimina (?) sp.	..	..	..	..	..	..	..	..	..	..	×	n.r.S. ..	..	..	×	..	..	..
	Endothyra (?) sp.	..	..	..	..	..	..	..	..	..	..	×	n.r.S. ..	..	..	×	..	..	..
*	Frondicularia Woodwardi (Howchin)	..	..	..	..	..	..	..	×	×	..	..	k.M. ..	..	..	..	..	..	..
*	Nodosaria Irwinensis (Howchin)	..	..	..	..	..	..	..	×	×	..	..	k.M. ..	..	..	..	..	..	..
	Pulvinulina exigua (?) (Brady)	..	..	..	..	..	..	..	..	..	..	×	n.r.S. ..	..	..	×	..	..	..
	Truncatulina Haidingeri (D'Orb.)	..	..	..	..	..	..	..	..	..	..	×	n r.S. ..	..	..	×	..	..	..
	Valvulina plicata (Brady) ..	..	..	..	..	..	..	..	..	..	..	×	n.r.S ..	..	..	×	..	..	..

* These species are represented in the collection of Mr. Walter Howchin of the Adelaide University.

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality. Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.	Reference.	Exhibited. Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines. N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Sub-Kingdom COELENTERATA. Sub-Branch Cnidaria. Class Hydrozoa Stromatoporoidea.																		
W(?)	Actinostroma clathratum (Nich.)	×	..	..	..	..	..	..	..	..	..	..	I. ..	..	..	..	..	×	..
	Stromatopora concentrica (Goldf.)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	,, *placenta* (Phil.)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	,, *sp.*	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
W(?)	Stromatoporella Eifeliensis (Nich.)	..	×	..	..	..	..	..	..	..	..	..	I. ..	..	..	..	..	×	..
	Class Anthozoa. Sub-Class Tetracoralla.																		
W	*Amplexus nodulosus* (Phil.) ..	..	×	..	×	..	..	..	..	..	..	..	d.o. ..	..	..	..	..	..	..
W	,, **pustulosus** (Hud!.) ..	..	×	×	×	..	×	..	×	..	..	..	D.I.n.o.p.	×	..	..	×	×	..
	,, **Selwyni** (de Kon.) ..	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
W	**Cyathophyllum depressum** (Hinde)	×	×	..	..	..	..	..	..	..	..	..	I.o.r. ..	×	..	..	..	..	..
W	,, **virgatum** (Hinde)	×	×	..	..	..	..	..	..	..	..	..	I.o.r. ..	×	..	..	..	..	..
	,, *sp.* ..	×	..	..	..	..	..	..	..	..	..	..	d.e.o.r...	..	..	..	..	..	..

	Lithostrotion (*Lithodendron*) *affine* (Flem.)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	,, *sp.*	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
W	**Pleurophyllum** (1) **Australe** (Hinde)	..	×	×	..	×	×	..	×	×	..	..	I.j.n.o.p.r. S.	×	×	..	×	×	..
W	,, **sulcatum** (Hinde)	..	×	..	..	..	×	..	×	×	..	..	I.j.o.s. ..	×	..	..	×	..	..
W	**Zaphrentis** *sp.*	×	×	..	×	..	..	..	..	..	..	..	d.e.o.r...	×	..	..	..	..	..
	Sub-Class Hexacoralla. Order Madreporaria. Sub-Order Tabulata.																		
W	**Alveolites obscurus** (de Kon.) ..	..	×	..	..	..	..	×	..	..	..	..	.. ..	×	..	..	..	..	..
	Chætetes tumidus (Phill.) ..	×	×	..	×	..	..	..	..	..	..	..	c.o.r. ..	..	..	..	..	..	..
	Favosites sp.	..	..	..	..	..	..	..	..	..	..	..	.. ..	..	..	..	..	..	..
W	**Hexagonella** (**Evactinopora**) **crucialis** (Hudl.)	×	×	..	×	×	×	×	×	..	..	..	D.n.o.P.r.	×	×	..	×	..	..
W	,, ,, **dendroidea** (Hudl.)	×	×	..	×	×	×	×	×	..	..	..	D.I.n.p.r.	×	×	..	×	×	..
	,, ,, sp.	×	..	..	..	..	..	..	..	..	..	..	g. ..	..	..	..	(?)	..	..
W	*Pachypora tumida* (Hinde) ..	×	×	..	..	..	..	..	..	..	..	..	I.o.r. ..	..	..	..	..	..	..
	,, *sp. nov.*	..	×	..	×	..	..	..	..	..	..	..	d. ..	..	..	..	..	..	..
	,, **sp.**	×	×	..	×	..	..	..	..	..	..	..	.. ..	×	..	..	..	..	..
	Stenopora Leichardti (Nich. & Eth.)	..	..	..	..	..	..	..	×	..	..	..	q. ..	..	..	×	..	..	..
W	,, *Tasmaniensis* (Lonsd.)	×	×	..	×	..	×	..	..	..	..	..	d.e.o.r...	..	..	..	..	..	..
	,, sp.	×	..	..	..	..	..	..	..	..	..	..	g. ..	..	..	..	(?)	..	..
W	**Syringopora reticulata** *var.* **patula** (Hinde)	..	×	..	..	..	..	..	..	..	..	..	I.o.r. ..	×	..	..	..	..	..
	,, *sp.*	×	×	..	..	..	..	..	..	..	..	..	e.i.o.r. ..	..	..	..	..	..	..

(1) In the original article by Dr. G. J. Hinde the word is spelt Plerophyllum. All subsequent authorities quote the name as given in this list.

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Sub-Kingdom ECHINODERMATA. Sub-Branch Pelmatozoa. Class Crinoidea. Order Larviformia.	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Symbathocrinus sp. (*fide* F. A. Bather)	..	..	..	..	..	..	..	×	..	..	..	.. ..	..	..	..	..	×	..
	Order Camerata.																		
	Actinocrinus (?) *sp.*	×	×	..	..	..	..	..	×	×	..	..	e.I.o.q.r.v.	×	..	×	..	..	..
	Platycrinus *sp.*	×	×	..	..	..	..	..	..	×	..	..	e.o.r.v...	×	..	..	..	..	..
W	*Poteriocrinus crassus* (Miller) ..	×	×	..	×	..	×	..	..	..	..	..	d.e.o.r...	..	..	..	..	..	..
	Rhodocrinus (?) *sp.*	×	×	..	..	..	..	..	..	..	..	..	I. ..	..	..	..	..	..	..
	Order Fistulata.																		
W	*Cyathocrinus sp.*	..	..	..	×	..	..	..	..	..	..	..	d.o. ..	..	..	..	..	..	..
	Crinoid head	..	×	..	..	×	..	..	..	..	..	..	.. ..	×	..	..	..	..	..
	.. **stems, etc.**	×	×	×	×	×	×	×	×	×	..	..	n.r.s.u.v.	×	×	×	×	×	×

	Class Blastoidea. Order Regulares.																	
	Pentremites sp.	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Sub-Kingdom Vermes. Sub-Order Tubicola (Sedentaria).																		
	Serpula spp.	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Spirorbis ambiguus (Flem.) ..	..	×	..	..	×	..	..	..	..	..	..	P. ..	×	..	..	..	..	..
(?)	,, *omphalodes* (Goldf.)	..	×	..	..	..	..	..	..	..	..	..	i. ..	..	..	..	..	..	..
	,, *spp.*	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Sub-Kingdom Molluscoidea. Class Bryozoa. Order Gymnolæmata. Sub-Order Cylcostomata.																		
	Ceriopora sp.	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Sub-Order Cryptostomata.																		
W	**Fenestella plebeia** (McCoy) ,, **fossula** (Lonsd.)	×	×	..	×	..	×	..	×	×	..	..	d.e.o.r.S.v.	×	..	..	..	..	..
	,, **plebeia** *var.* **densa** (Eth. fil.)	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..
	,, **spp.**	×	×	..	..	..	..	×	×	×	×	..	o.r. ..	×	..	..	..	..	..
W	**Polypora Australis** (Hinde) ..	..	×	..	..	..	..	..	..	..	..	..	I.o. ..	×	..	..	..	..	..
W	**Protoretepora ampla** (Lonsd.) ..	..	×	..	×	..	×	×	×	×	×	..	d.i.o. ..	×	..	..	..	..	..
	,, *antiqua* (Lonsd.)	×	×	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
W	Rhombopora tenuis (Hinde) ..	..	×	..	..	×	×	..	..	..	..	..	I.n.o.r.u.	..	..	..	..	×	..

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Class Brachiopoda. Order Neotremata.	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Crania sp.	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
	Discina sp.	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Order Protremata.																		
	Aulosteges Baracoodensis (Eth. fil.)	..	×	..	..	..	×	×	×	×	..	..	n.P.r.u.v.	×	..	..	×	..	..
	Chonetes Hardrensis (Phil.) ..	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
W	,, **Pratti** (Davidson) ..	..	×	×	×	×	×	..	×	×	..	..	J.n.o.p.r.S. u.v.	×	..	..	×	×	..
W	,, **spp.** (*non* **pratti**) ..	×	..	..	..	..	..	..	..	..	×	..	h.I.n.o.r.S. v.	×	..	..	(?)	×	×
	Derbyia sp. *c.f.* **senilis** (Phil.) (?)	..	..	..	..	..	..	..	×	×	..	..	q. ..	×	..	×	..	..	..
	Orthis resupinata (Martin) ..	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	,, *c.f.* **Michelini** (Martin) ..	..	×	..	..	..	..	×	..	..	..	..	.. ..	×	..	..	..	..	..

W	„ **spp.**	×	×	..	×	..	..	×	..	..	×	..	d.e. ..	×	..	..	..	..	..
W	**Orthotetes (Streptorhynchus)** (2) **senilis** (Phill.)	×	×	..	..	..	..	..	×	×	..	..	e.i.j.o.p.r.v	×	..	×	..	..	..
W	**Productus brachythærus** (Sowerby)	×	×	..	×	..	..	..	×	×	×	..	d.g.h.r.s.	×	×	..	(?)	..	..
	„ „ *var.* (**Eth. fil.**)	..	..	..	..	..	..	..	×	×	..	..	s. ..	×	..	..	..	..	..
	„ Cora (d'Orb.) ..	..	..	..	..	..	..	..	×	×	..	..	.. ..	..	..	×	..	..	..
	„ *c.f.* **Cora** (d'Orb.) ..	..	×	..	..	..	×	..	..	..	..	..	.. ..	×	..	..	×	..	..
	„ *giganteus* (Mart.) ..	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	„ *longispinus* (Sowerby)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	„ *c.f.* **margaritaceus** (Phill.)	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	„ **scabriculus** (Mart.) ..	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	„ **semireticulatus** (Mart.)	×	×	×	×	×	×	..	×	×	..	..	e.n.o.P.r. s.u.v.	×	..	..	×	..	..
	„ „ *var.* **pugilis** (Phill.)&	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
	„ *c.f.* **spiralis** (Waagen) and **subcostatus** (Waagen)	..	×	..	..	..	×	..	..	..	..	..	.. ..	×	..	..	..	..	..
W	„ **subquadratus** (Morris)	..	..	..	..	..	..	×	×	×	×	..	I.j.n.o.r. S.v.	×	×	..	×	×	..
W	„ **tenuistriatus** (De Vern.)	..	×	..	..	×	..	..	×	×	..	..	I.j.o.r.s.u.	×	×	..	×	×	..
	„ „ *var.* **Foordi** (Eth. fil.)	..	×	..	..	×	..	..	×	×	..	..	n.P.r.S.v.	×	×	..	..	..	..
W	„ **undatus** (Defr.) ..	..	×	..	..	..	..	..	×	×	..	..	I.j.o.q.r.s. v.	×	×	×	×	×	..
	„ **spp.**	×	×	..	×	..	×	..	×	×	..	..	d.e.g.n.u.v.	×	..	..	(?)	..	×
	Strophalosia Clarkei (Eth. fil.)	×	×	×	..	..	..	..	×	×	..	..	I.n.o.q.r.	×	..	×	..	×	..
	„ *c.f.* Gerardi (King)	..	..	..	..	..	..	..	×	..	..	..	h. ..	..	..	..	(?)	..	..
	„ **sp.**	..	×	×	×	..	..	..	..	..	..	..	d.P. ..	×	×	..	..	..	..
	Strophomena **analoga** (Phil.) ..	..	..	..	..	..	..	..	×	..	..	..	h. ..	×	..	..	(?)	..	..
	„ **sp.**	..	×	×	..	..	..	..	×	×	..	..	u.v. ..	×	..	..	..	..	..

(1) *Vide* also Orthotetes below and Chapman, Proc. Royal Soc. Vict., Vol. XIII., p. 323, 1904.

(2) Sometimes quoted as Streptorhynchus crenistria, or O. crenistria.

CARBONIFEROUS—*continued*.

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Order Telotremata.	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Actinoconchus *c.f.* **planosulcatus** (Phill.)	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	,, **sp.** (*or* **Cleiothyris** sp.)	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	Atrypa sp.	×	..	..	..	..	..	..	..	..	..	..	e.						
	,, (?) **sp.**	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
	Athyris ambigua (Sowerby) ..	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
	,, **sp.**	..	×	..	×	..	..	..	..	..	..	..	u. ..	×	..	..	..	..	..
W	**Cleiothyris (Athyris) Macleayana** (Eth. fil.)	×	×	×	..	×	×	×	×	×	×	..	G.I.n.o.P. r.s.u.v.	×	×	..	×	×	..
	,, ,, *var.* **Baracoodensis** (Eth. fil.)	..	×	..	..	..	×	..	..	..	..	..	P. ..	×	×	..	..	..	..
	,, ,, **sp.** *near* **Macleayana** (Eth. fil.)	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
W	,, ,, **Roysii** (Lev.)	..	×	..	×	..	..	×	..	..	..	..	d.o. ..	×	..	..	..	..	..
	,, ,, **sp.** ..	×	..	..	..	..	..	..	×	..	..	..	e.n. ..	×	..	..	..	..	..

	Cyrtina carbonaria *var.* **Australasica** (Eth. fil.)	×	..	..	..	..	..	..	..	..	×	..	G.n.r.s.v.	×	..	..	(?)	..	..
	Dielasma (Terebratula) nobilis (Eth. fil.)	..	..	..	..	..	..	..	..	..	×	..	n.r.S.v.	×	×	..	..	..	..
	,, ,, **sacculus** (Martin)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	×	..	..	..	..	..
	,, ,, **hastata** (Sowerby)	×	..	..	..	..	..	..	..	..	×	..	e.o.r.v...	×	..	..	..	..	..
	,, ,, **amygdala** (Dana) (?)	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..
	,, ,, **cymbæformis** (Morris) (?)	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..
	,, ,, ,, **var** (?)	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..
	,, ,, **sp.** ..	×	×	..	..	..	×	×	×	×	×	..	e.r.S.u.v.	×	..	..	..	..	..
	,, ,, **sp. ind.**	..	×	..	..	..	×	..	..	..	..	..	n.r. ..	×	..	..	..	..	..
W	**Reticularia crebristria** (Morris)..	..	..	..	..	..	..	..	×	..	..	..	i.j.o.v. ..	×	..	..	..	..	..
W	,, **lineata** (Martin) ..	..	×	..	..	×	..	..	×	×	..	..	i.j.n.o.p.r. s.u.v.	×	..	..	×	..	..
	Retzia sp.	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
	Rhynchonella (Hypothyris) cuboides (J. de C. Sowerby.)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	×	..	..	..	..	..
	,, ,, **pleurodon** (Phill.)	×	..	..	..	..	..	..	×	..	..	..	e.o.r. ..	×	..	..	..	..	..
	,, ,, **pugnus** (Mart.)	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	×	..	..	..	..	..
	Seminula subtilita (Hall) (?) ..	×	×	..	..	..	×	..	×	×	..	..	P.r.S.v.	×	×	×	..	..	..
	,, **sp.**	..	×	..	..	..	×	..	..	..	..	..	.. ..	×	..	..	..	..	..
	Spirifera avicula (Sowerby) ..	..	..	..	..	..	..	..	..	..	×	..	r. ..	×	×	..	..	..	..
W	,, **convoluta** (Phill.) ..	..	×	..	..	..	×	×	×	..	..	..	.. ..	×	..	..	×	..	..
-	,, *c.f.* **convoluta** (Phill.)	..	×	..	..	..	×	..	×	..	..	..	d.o. ..	×	..	×	..	..	..
W	,, *c.f.* **crassus** (De Kon.)	..	×	..	×	..	×	..	..	..	..	..	d.o. ..	×	..	..	..	..	..
	,, **disjuncta** (Sowerby) ..	..	..	..	..	..	..	..	×	×	..	..	.. ..	..	..	..	..	..	×
	,, **(Martinia) glabra** (Martin)	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Order Telotremata—*continued.*	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum.	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
W	**Spirifera Hardmani** (Foord) ..	×	×	..	..	×	×	..	×	×	..	..	I.n.o.P.r. u.v.	×	×	..	×	×	..
W	,, **Kimberleyensis** (Foord)	..	×	..	..	..	×	..	×	..	..	..	I.o. ..	×	..	..	..	..	..
W	,, **lata** (McCoy) ..	..	×	..	×	×	×	×	×	..	..	..	I n.o.r.u.v.	×	..	..	..	..	..
	,, ,, **var.** with ribbed sulcus	..	×	..	..	×	..	..	..	..	..	..	P. ..	×	..	..	..	..	..
W	,, **Musakheylensis** *var.* **Australis** (Foord)	..	×	..	..	×	×	×	×	×	..	..	I.j.n.o.P.r. u.v.	×	×	..	..	..	..
W	,, **striata** (Martin) ..	×	×	..	×	×	×	..	..	..	..	..	d.e.o. ..	×	..	..	..	..	..
	,, *c.f.* **striata** (Martin) ..	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	×	..	..
	,, **Stutchburyi** (?) (Eth. fil.)	..	..	..	..	..	..	..	..	..	×	..	p. ..	×	×	..	..	..	..
	,, (Martinopsis) subradiata (Sowerby)	..	×	..	..	..	..	..	..	..	..	..	.. ..	..	..	×	..	..	..
	,, **trigonalis** (Martin) ..	..	×	..	×	..	×	×	×	×	..	..	.. ..	×	..	..	×	..	×
W	,, **vespertilio** (G. Sowerby)	..	×	..	..	..	×	..	..	..	..	..	d.o. (?)	×	..	..	..	..	..
	,, **spp.**	×	×	..	..	×	×	×	×	×	×	..	e.g.n.P.r. S.u.v.	×	×	..	(?)	..	..
	,, **sp.** (*or* **Martinopsis sp.**)	×	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
W	**Syringothyris exsuperans** (De Kon.)	..	×	..	..	..	×	..	×	×	..	..	i.j.o.v. ..	×	..	×	×	×	..

	Sub-Kingdom Mollusca. Class Pelecypoda. Order Prionodesmacea.																		
	Anthracoptera sp.	..	×	..	..	..	×	..	..	..	..	..	r.u. ..	×	×	..	..	..	..
	Arca (?) **sp.**	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	Aviculopecten granosus (J. de C. Sowerby.)	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
	,, **multiradiata** (Eth. sen.)	..	×	..	..	..	..	..	..	..	..	..	.. ..	×	..	..	..	..	..
	,, **Sprenti** (Johnst.)	..	..	..	..	..	..	..	×	×	..	..	r.S.v. ..	×	×	..	..	..	..
W	,, **tenuicollis** (Dana)	×	×	×	..	×	×	..	×	×	..	..	g.I.P.r.u.v	×	..	..	..	×	..
	,, **spp.**	..	×	×	..	×	×	×	×	×	×	..	e.h.i.n.o.r. S.v.	×	..	..	..	..	..
	Cardiomorpha oblonga (Sowerby)	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
	Chænomya (?) **sp.**	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	Conocardiam (**Pleurorhynchus**) **sp.**	×	..	..	..	..	..	..	×	×	..	..	e.r.s.v.	×	..	..	..	..	..
	,, ,, (?) **sp.**	..	..	..	..	..	..	..	×	×	..	..	.. ..	×	..	..	..	..	..
	Conocardiam Hibernicum (?) (Sowerby)	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
W	**Deltopecten** (**Aviculopecten**) **Illawarensis** (Morris) (?)	..	×	..	..	..	×	×	..	..	..	..	d.o. ..	×	..	..	..	..	..
	,, ,, **leniusculus** (Dana)	..	×	..	..	..	..	..	..	..	..	..	.. ..	×	..	..	..	..	..
W	,, ,, **limæformis** (Morris)	..	×	..	×	..	×	..	..	..	..	..	d.o. ..	×	..	..	..	..	..
	,, ,, **subquinque lineatus** (McCoy)	..	..	..	..	..	..	..	..	..	×	..	n.r.S.v.	×	×	..	..	..	..
	,, .. **spp.**	..	..	..	..	..	..	..	..	×	×	..	h. ..	×	..	..	×(?)	..	..
W	**Edmondia spp.**	×	..	..	..	..	..	..	×	×	×	..	g.i.o.v.	×	..	..	..	..	..
W	**Modiola spp.**	×	..	..	..	..	..	..	×	×	×	..	i.n.o.r.S.v	×	..	..	..	..	..
	Myalina (?) **Mingenewensis** (Eth. fil.)	..	..	..	..	..	..	..	..	..	×	..	n.r.S.v.	×	×	..	..	..	..
	,, **spp.**	..	×	..	..	..	×	×	..	..	×	..	.. ..	×	×	..	..	..	..
	Mytilops (?) **sp.**	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Order Prionodesmacea—*contd.*	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Mytilus spp.	×	..	..	..	..	..	..	..	..	×	..	e. ..	×	..	..	..	..	..
	,, **sp.** (*or* **Modiomorpha**)	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	×	..	..	..	..
	Parallelodon (Palæarca) subarguta (De Kon.)	×	..	..	..	..	..	..	×	..	..	..	g.h. ..	×	..	..	(?)	..	..
	,, **sp.** (**Macrodon sp.**)	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
	Pterinea (Merismoptera) macroptera (Morris)	×	..	..	..	..	..	..	..	..	..	..	g. ..	..	..	..	(?)	..	..
	Sanguinolites *c.f.* Hibernicus (Hind)	..	..	..	..	..	..	..	×	..	..	..	q. ..	..	..	×	..	..	..
W	,, **sp.**	..	..	..	..	..	..	..	×	×	×	..	i.o.v. ..	×	..	..	..	..	..
	Stutchburia *c.f.* **Randsi** (Eth. fil.)	..	..	..	..	..	..	..	..	×	..	..	v. ..	×	..	..	..	..	..
	,, **sp.**	..	..	..	..	..	..	..	..	×	..	..	r.S.v. ..	×	..	..	..	..	..
	Order Anomalodesmacea.																		
	Allorisma *c.f.* curvatum (Morris)	..	..	..	..	..	..	..	×	..	..	..	q. ..	..	..	×	..	..	..
	,, *c.f.* maximum (Portl.)	..	..	..	..	..	..	..	×	..	..	..	q. ..	..	..	×	..	..	..

	Order Teleodesmacea.																		
	Curtonotus elegans (Salter) ..	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
W	**Pleurophorus (Pachydomus) carinatus** (1) (Morris)	..	×	..	..	..	..	×	×	..	..	..	i.j.o. ..	×	..	..	..	..	..
	,, ,, **spp.**	×	..	..	..	..	..	..	×	..	..	..	g.h.v. ..	×	×	..	(?)	..	..
	Class Gastropoda. Sub-Class Streptoneura. Order Aspidobranchia. Sub-Order Rhipidoglossa.																		
	Baylea (Ivania) Levellii (De Kon.)	..	..	..	..	..	..	..	×	..	..	..	.. ..	×	..	..	..	..	..
	Bellerophon costatus (J. de C. Sowerby)	..	..	..	..	..	..	..	×	×	..	..	r.S.v. ..	×	..	..	..	..	..
W	,, **decussatus** (Flem.) (?)	..	..	..	..	..	..	..	×	..	..	..	i.j.o. ..	×	..	..	..	..	..
	,, *Urei* (Flem.)	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
	,, **sp.**	×	..	..	..	..	..	..	×	×	..	..	e.v. ..	×	..	..	..	..	..
W	**Euomphalus spp.**	×	..	..	..	..	..	..	×	..	..	..	v. ..	×	..	..	..	..	..
	,, (?) **spp.**	×	..	..	..	..	..	..	×	..	..	..	I. ..	×	..	..	..	×	..
	Euphemus Orbignii (Portl.) ..	×	..	..	..	..	..	..	..	..	..	..	g. ..	..	..	..	(?)	..	..
	Mourlonia (Pleurotomaria) humilis (De Kon.)	×	..	..	..	..	..	..	..	..	..	..	g. ..	..	..	..	(?)	..	..
	Pleurotomaria spp.	×	..	..	..	..	..	..	..	×	..	..	e.o.r.v...	×	..	..	..	..	×
W	,, (?) **sp.** ..	×	..	..	..	..	..	..	..	..	..	..	e.I.o.r...	..	..	..	..	×	..
	Ptychomphalina Maitlandi (Eth. fil.)	..	×	×	..	..	..	..	..	..	×	..	n.P.u. ..	×	..	..	..	..	..
	,, **sp.**	..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..

(1) Or Mæonia carinata (Morris) fide Eth. fil. Geol. and Pal., Queensl., p. 283.

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Order Ctenobranchia. Sub-Order Platypoda.	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooranel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Acroculia (Platyceras) sp. ..	..	..	..	..	..	..	..	×	×	..	..	v. ..	×	..	..	..	..	..
	Loxonema sp.	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Natica sp.	×	..	..	..	..	..	..	..	..	..	..	e.o.r. ..	..	..	..	..	..	..
	Class Cephalopoda. Sub-Class Tetrabranchiata. Order Nautiloidea. Sub-Order Orthochoanites.																		
	Cæloanutilus Chesterensis (De Kon.)	..	..	..	..	..	..	..	..	×	..	..	.. ..	×	..	..	..	..	..
W	**Discites** *c.f.* **Omalianus** (De Kon.)	..	..	..	..	..	..	..	×	..	..	..	i.j.o. ..	×	..	..	..	..	..
	,, **sp.**	..	..	..	..	..	..	..	×	..	..	..	i.j.o. ..	×	..	..	..	..	..
	Nautilus (?) **sp.** (*Mesozoic* ?) ..	..	..	..	..	..	..	..	..	×	..	..	.. ..	..	..	..	..	..	×
W	**Orthoceras spp.**	×	..	..	..	..	..	..	×	×	..	..	e.i.j.o.v.	×	..	..	..	×	..

	Sub-Order Cyrtochoanites.																			
	Actinoceras sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
	Order Ammonoidea. Sub-Order Eurycampyli.																			
	Gastrioceras Jacksoni (Eth. fil.)	..	..	..	..	..	..	..	×	..	..	..	r.S.	..	×	..	..	..	..	..
	Glyphioceras sphæricum (Goldf.)	×	..	..	..	..	..	..	..	..	..	..	e.	..	×	..	..	..	..	..
	,, **sp.**	×	..	..	..	..	..	..	..	..	..	..	e.	..	×	..	..	..	..	..
	,, (?) sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
	Sub-Order Phyllocampyli.																			
W	**Agathiceras micromphalum** (Morris)	×	..	..	..	..	..	..	×	..	..	..	I.q.	..	×	..	×	..	×	..
	Sub-Order Pachycampyli.																			
	Brancoceras sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
	Sub-Kingdom ARTHROPODA. Class Crustacea. Sub-Class Trilobita. Order Opisthoparia.																			
	Phillipsia grandis (Eth. fil.) ..	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..

PALÆOZOIC—*continued.*

CARBONIFEROUS—*continued.*

	Genus and Species.	Locality.											Reference.	Exhibited.					
	Super-Order Ostracoda.	Kimberley.	Gascoyne.	Minilya River.	Lyons River.	Wyndham River.	Gascoyne River.	Wooramel River.	Irwin.	Irwin River Coal.	Mingenew P.C.	Collie Coalfield.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Dept. of Mines, N.S.W. Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Various species	..	×	..	..	..	×	..	..	..	..	..	.. ..	×	..	..	..	..	..
	Crustacean tracks (?)	..	×	×	..	..	..	..	..	..	..	..	n.P. ..	×	..	..	..	..	..
	VERTEBRATA. Class Pisces. Sub-Class Selachii.																		
W	**Edestus Davisii** (H. Woodw.) ..	..	×	..	..	..	×	..	..	..	..	..	F.o. ..	×	..	..	..	..	..
	Pœcilodus Jonesi (Ag.) ..	×	..	..	..	..	..	..	..	..	..	..	e. ..	..	..	..	..	..	..
	Small tooth	×	..	..	..	..	..	..	..	..	..	..	e.v. ..	×	..	..	..	..	..

PART II.

Mesozoic Fossils.

Rocks containing animal remains of Mesozoic age cover a fair percentage of the sedimentary area of the State. The beds consist for the most part of yellowish, reddish, or brownish ferruginous sandstones, occasionally containing a large amount of calcareous matter, and even passing into yellowish limestone bands that are highly crystalline and full of fossils, all showing a typically Jurassic facies. Naturally the sandstones, though often very fossiliferous, are not remarkable for the good state of preservation of the animal remains they contain. Still, numerous excellent specimens have been obtained by the officers of this Department and have been incorporated in the Geological Survey Collection, now on exhibit in the Geological Gallery of the Western Australian Museum.

One of the earliest geological observers in the colony, F. T. Gregory, reported the presence of the Cretaceous strata near Gin Gin, in the form of chalk, and records the collection of Ammonites, etc., from the beds, thus giving them a truly Mesozoic facies. Subsequent authorities seem to have placed little faith in this discovery, reported in the Q. J. G. S., Vol. XVI. 1861, pp. 475–483, especially as one of the Lamellibranchs (Pelecypods) was found to be a truly Jurassic form *Trigonia Moorei* (Lycett). There seems little doubt, however, that these beds are homotaxial with the Cretaceous of Europe when the whole of the known Gingin fauna is considered. (*Vide* Article VIII., p. 115, *et. seq*).

In this portion of the list, the same general plan adopted in Part 1 has been followed, but it has been thought advisable to introduce a column for doubtful or vague localities which are distinguished as under :—

"Western Australia"	1
Champion Bay	2
Gascoyne River District	3

MESOZOIC.

Jurassic only.

Genus and Species.	Locality.										Reference.	Exhibited.					
Sub-Kingdom Protozoa. Class Rhizopoda. Order Foraminifera.	Shark Bay.	Moresby Range.	Greenough R.	Tibradden.	Moonyoonooka.	Sandspring.	Woolanooka.	Snake Farm.	Mount Hill.	Doubtful Locs.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Bath Museum.	British Museum.	Geol. Soc. Lond. Museum.
Bulimina Gregorii (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
Cristellaria costata *var.* compressa (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, ,, *var.* seminuda (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, cultrata *var.* radiata (Moore)	..	..	..	..	..	..	..	..	..	1	b.(c.)o.	..	..	..	×	..	..
,, Daintreei (Chapm.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, decipiens (Wisnow.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, *c.f.* limata (Schw.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, prominula (Reuss) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, rotulata (Lamarck) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, subalata (Reuss)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
Discorbina rosacea (D'Orb.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
Flabellina dilatata (Wisnow.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
Haplophragmium neocomianum (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
Marginulina compressa (D'Orb.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, solida (Terquem) ..	..	..		..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
Polymorphina burdigalensis (D'Orb.) ..	..	..		..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, compressa (D'Orb.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
,, gutta (D'Orb.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..

	Textularia crater (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
	Truncatulina Wuellerstorfi (Schw.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
	Vaginulina intumescens (Reuss) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
	,, lata (Corn.)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
	,, Schloenbachi *var.* interrupta (Reuss)	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
	,, strigillata (Reuss.) ..	..	..	×	..	..	..	..	..	..	..	Q.	..	..	×	..	..	..
	Sub-Kingdom Echinodermata. Sub-Branch Pelmatozoa. Class Crinoidea. Order Articulata.																	
	Pentacrinus spp.	..	×	..	..	..	..	..	..	..	1	b.	..	..	..	×	..	..
	Sub-Branch Echinozoa. Class Echinoidea.																	
W	*Spines of Echini*	..	..	..	..	..	..	..	..	..	1	b.	..	..	..	..	..	..
	Sub-Kingdom Vermes. Sub-Order Tubicola (Sedentaria).																	
W	**Serpula conformis** (Goldf.) .. .. ,, spp.	.. ..	.. ×	.. ..	× ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	T. a.b.	× ..	.. ..	.. ..	.. ×	.. ..	.. ..
	Sub-Kingdom Molluscoidea. Class Bryozoa.																	
W	*Bryozoa*	×	×	..	..	..	..	..	..	..	..	b.	..	..	..	..	..	..

MESOZOIC—*continued.*

JURASSIC ONLY—*continued.*

	Genus and Species.	Locality.										Reference.	Exhibited.					
		Shark Bay.	Moresby Range.	Greenough R.	Tibraddon.	Moonyoonooka.	Sandspring.	Woolanooka.	Snake Farm.	Mount Hill.	Doubtful Locs.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Bath Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Class Brachiopoda. Order Telotremata.																	
W	**Rhynchonella variabilis** (Schl.) ..	×	×	..	..	×	..	..	×	×	1	a.B.c.o.T.	×	..	..	×	..	..
	,, *c.f.* solitaria (Moore) ..	..	×	..	..	..	..	..	..	..	..	.. ..	..	..	×	..	..	..
	,, spp.	..	×	×	..	..	..	..	..	..	1	a.b. ..	..	..	..	×	..	..
	Sub-Kingdom MOLLUSCA. Class Pelecypoda. Order Prionodesmacea.																	
	Arca sp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
W	**Alectryonia (Ostrea) Marshii** (Sowerby)	×	×	×	×	×	×	×	..	×	..	a.b.c.o.T.	×	×	..	..	..	..
	,, ,, c.f. Marshii (Sowerby)	..	×	×	..	..	..	..	..	..	..	.. ..	..	..	×	..	..	..
	Avicula æqualis (Moore)	..	×	..	..	..	..	..	..	..	..	(c.) ..	×	..	..	×	..	..
	,, (Maccoyella) Barklyi (Moore)	..	..	..	..	..	..	..	..	..	1	B.(c.) ..	..	..	..	×	×	..
W	,, *echinata* (Sowerby)	..	×	×	..	..	..	..	..	..	..	b.c.o. ..	..	..	..	..	..	..
W	,, *inæquivalvis* (Sowerby) ..	..	×	..	..	..	..	..	..	..	1	b.c.o. ..	..	..	..	..	..	..
W	,, *Munsteri* (Bronn.)	..	×	..	..	..	..	..	..	..	..	a.b.c.o.	..	..	..	..	..	..
	,, spp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
	Ctenostreon (Lima) pectiniformis (Schl.)	..	×	×	×	×	×	×	..	×	2	r.Q.T. ..	×	×	×	×	..	..
	Cucullæa inflata (Moore)	..	..	×	..	..	..	..	..	..	..	B.c.o. ..	..	..	..	×	..	..
	,, *c.f.* **inflata** (Moore).. ..	..	..	..	..	..	×	..	..	..	..	T. ..	×	×	..	..	..	..

W	,, oblonga (Sowerby)	×	×	..	..	..	..	..	..	..	1	b.c.o. ..	..	..	..	×	..	..
W	,, **semistriata** (Moore) ..	..	×	×	×	×	×	×	..	×	2	B.c.o.q.r.T	×	×	×	×	..	..
	,, *c.f.* **semistriata** (Moore) ..	..	..	..	..	..	..	..	..	×	..	.. ..	×	..	..	..	..	..
	,, **tibraddonensis** (Eth. fil.) ..	..	..	..	×	..	×	..	..	..	..	T. ..	×	×	..	..	..	..
	,, **spp.**	×	×	×	..	×	×	..	..	×	1	a.b.T. ..	×	..	..	×	..	..
	Gryphæa spp.	..	×	×	..	×	..	..	..	..	2	r. ..	×	..	×	..	..	..
	Hinnites sp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
	Lima Gordonii (Moore)	..	..	..	..	..	..	..	..	..	1	B. ..	..	..	..	..	×	..
W	,, proboscidea (Sowerby) ..	×	×	..	..	..	..	..	..	..	1	a.b.c.o.	..	..	..	×	..	..
W	,, punctata (Sowerby)	×	..	..	..	..	..	..	..	..	1	b.c.o. ..	..	..	..	×	..	..
	,, *spp.*	..	×	×	..	..	..	..	..	×	2	a.b.r. ..	..	..	..	..	..	..
	Modiola Maitlandi (Eth. fil.)	..	..	..	×	×	×	..	..	×	..	T. ..	×	×	..	..	..	..
	Mytilus c.f. gygerensis (D' Orb.) ..	..	..	..	..	..	..	..	..	..	2	a.r. ..	..	..	..	..	..	..
	,, *sp.*	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
	Nucula sp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
	Ostrea tholiformis (Eth. fil.)	..	..	..	×	×	×	×	×	×	..	T. ..	×	×	..	..	..	..
	,, *c.f.* **tholiformis** (Eth. fil.) ..	..	..	..	..	×	..	..	×	×	..	.. ..	×	..	..	..	..	..
	,, **spp.**	..	..	×	×	×	×	..	..	×	..	b.T. ..	×	..	..	..	..	..
	,, **sp.** (very small)	..	×	..	..	..	..	..	..	×	..	a. ..	×	..	..	..	..	..
W	Pecten calvus (Goldf.)	×	×	..	..	..	..	..	..	..	1	b.c.o. ..	..	..	..	×	..	..
W	,, **cinctus** (Sowerby)	×	×	×	×	×	×	×	×	×	1	b.c.o.q.T.	×	×	×	×	..	..
	,, *c.f.* **frontalis** (Dum.)	..	..	×	..	×	..	..	..	..	..	r. ..	×	..	..	..	..	..
	,, **Greenoughiensis** (Moore) ..	..	..	×	..	..	..	..	..	×	..	B.c.o. ..	×	..	..	..	..	..
	,, **valoniensis** (Defr.)	..	..	..	..	..	..	..	..	..	3	.. ..	×	..	..	..	..	..
	,, *c.f. vesicularis*	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
	,, **spp.**	..	×	..	×	×	×	..	..	..	..	a.T. ..	×	×	..	..	..	×
	,, **sp.** (*or* **Ctenostreon sp.**) ..	..	..	..	×	..	..	..	..	..	..	.. ..	×	..	..	..	..	..
	Perna sp. (*or* **Inoceramus sp.**)	..	..	..	×	..	..	..	..	..	..	.. ..	×	..	..	..	..	..
W	*Plicatula sp.*	..	×	..	..	..	..	..	..	..	1	b. ..	..	..	..	..	..	..
W	**Radula (Lima) duplicata** (Sowerby) ..	..	×	..	×	..	×	..	×	×	1	b.c.T. ..	×	..	..	×	..	..
	,, ,, *sp.*	..	×	..	..	..	..	..	..	×	..	a. ..	..	..	..	..	..	..
W	**Trigonia Moorei** (Lycett)	×	×	×	×	×	×	×	×	×	3	B.c.o.q.r. T.	×	×	×	×	×	..
	,, *costata* (Clarke) (? *Moorei*) (Lyc)	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
	,, sp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	×

MESOZOIC—*continued.*

JURASSIC ONLY—*continued.*

	Genus and Species.	Locality.										Reference.	Exhibited.					
	Order Anomalodesmacea.	Shark Bay.	Moresby Range.	Greenough R.	Tibradden.	Moonyoonooka.	Sandspring.	Woolanooka.	Snake Farm.	Mount Hill.	Doubtful Locs.		Geol. Soc. Lond. Museum.	Australian Museum	Victorian Museum.	Bath Museum.	British Museum.	Geol. Soc. Lond. Museum.
W	Gresslya donaciformis (Phill.) ..	×	..	×	..	..	..	..	..	..	1	b.c.o. ..	..	..	..	×	..	..
	,, *sp.*	..	..	..	..	..	..	..	..	..	2	b.r. ..	..	..	..	..	..	..
	,, (?) sp.	..	..	..	..	..	..	..	..	..	1	.. ..	..	..	..	×	..	..
	Homomya (?) sp,.	..	..	..	..	..	..	..	..	..	1	b.(c.) ..	..	..	..	×	..	..
W	**Myacites liassianus** (Quenst.)	×	..	..	..	..	..	..	..	..	1, 2	b.c.o. ..	×	..	..	×	..	..
W	,, **Sanfordii** (Moore)	..	..	×	..	×	..	..	..	×	1, 2	B.c.o.r.	×	×	..	×	..	..
	,, spp.	×	×	×	..	..	..	..	..	..	..	a.b. ..	..	..	..	×	..	..
W	**Pholadomya ovulum** (Agassiz) ..	×	..	×	..	..	..	..	..	..	1	b.c.o. ..	×	..	..	..	..	..
	,, *sp.*	..	×	..	..	..	..	..	..	..	..	a.b. ..	..	..	..	..	..	..
	Pleuromya sp. (?)	..	..	×	..	×	..	..	..	..	2	r. ..	×	..	..	..	..	..
	Order Teleodesmacea.																	
W	*Astarte apicalis* (Moore)	..	..	×	..	..	..	..	..	..	..	B.c.o. ..	..	..	..	..	..	..
W	,, **Cliftoni** (Moore)	×	..	×	×	×	..	×	..	×	2	B.c.o.q.r. T.	×	×	×	..	..	..
	,, **spp.**	×	×	×	..	..	..	..	..	×	2	a.b. ..	×	..	..	×	..	..

W	*Cardium sp.*	..	×	..	..	..	..	..	..	..	..	a.b.o.	..	..	..	..	..	..
W	Cypricardia sp.	×	..	..	..	..	..	..	..	..	..	b.o.	..	..	..	×	..	..
W	Isocardia sp.	×	..	..	..	..	..	..	..	..	..	b.o.	..	..	..	×	..	..
	Lucina sp. (? *Pseudavicula*, Eth. fil.)	..	×	..	..	..	..	..	..	..	..	a.	..	..	..	..	..	..
	Opis sp.	..	×	..	..	..	..	..	..	..	..	a.	..	..	..	..	..	..
	Panopæa (Glycimeris) rugosa (Moore)	..	..	..	..	..	..	..	..	..	2	..	×	..	..	..	..	..
	,, **sp. nov.**	..	..	..	..	..	..	..	..	..	2	..	×	..	..	..	..	..
	,, **sp.**	..	×	..	..	..	..	..	..	..	3	..	×	..	..	..	..	..
W	Tancredia plana (?) (Moore)	..	×	×	..	×	..	..	..	..	..	b.(c.)o.	..	×	..	..	..	..
W	Teredo (Pholas) Australis (Moore)	×	×	..	..	..	..	..	..	..	1	a.B.c.o.	..	..	..	×	..	..
W	*Unicardium sp.*	..	×	..	..	..	..	..	..	..	..	b.o.	..	..	..	..	..	..
	,, (?) sp.	..	×	..	..	..	..	..	..	..	..	*b.*	..	..	..	..	..	..
	Class Scaphopoda. Family Dentaliidæ.																	
	Dentalium sp.	..	×	..	..	..	..	..	..	..	..	a.	..	..	..	..	..	..
	Class Gastropoda. Order Aspidobranchia. Sub-Order Rhipidoglossa.																	
W	*Amberleya sp.*	..	×	..	..	..	..	..	..	..	..	b.o.	..	..	..	..	..	..
W	Phasianella sp.	×	..	..	..	..	..	..	..	..	1	b.o.	..	..	..	×	..	..
	Pleurotomaria Greenoughiensis (Eth. fil.)	..	..	..	..	..	×	..	..	..	..	T.	×	..	..	..	..	..
	,, **sp.**	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..
W	*Trochus sp.*	..	×	..	..	..	..	..	..	..	..	b.o.	..	..	..	..	..	..
	Turbo Australis (Moore)	×	..	×	..	..	..	..	..	..	..	B.c.o.	..	..	..	×	..	..
W	,, *lævigatus* (Sowerby)	..	×	×	..	..	..	..	..	..	..	b.c.o.	..	..	..	..	..	..
	,, *sp.*	..	×	..	..	..	..	..	..	..	..	a.b.	..	..	..	..	..	..

MESOZOIC—*continued.*

JURASSIC ONLY—*continued.*

	Genus and Species.	Locality.										Reference.	Exhibited.					
		Shark Bay.	Moresby Range.	Greenough R.	Tibraddon.	Moonyoonooka.	Sandspring.	Woolanooka.	Snake Farm.	Mount Hill.	Doubtful Locs.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Bath Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Order Ctenobranchiata. Sub-Order Platypoda.																	
W	*Cerithium Greenoughiensis* (Moore) ..	×	..	×	..	..	..	..	..	..	..	B.c.o. ..	..	..	..	..	..	..
	,, *sp.*	..	×	..	..	..	..	..	..	..	..	b. ..	..	..	..	..	..	..
	Chemnitzia sp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
W	*Eulima* (?) *sp.*	..	×	..	..	..	..	..	..	..	..	b.o. ..	..	..	..	..	..	..
	Nerinæa sp.	..	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	..	..	..
W	Rissoina Australis (Moore)	×	..	×	..	..	..	..	..	..	..	B.c.o. ..	..	..	..	×	..	..
	Order Opisthobranchia. Sub-Order Tectibranchiata.																	
	Actæon depressus (Moore)	×	..	..	..	..	..	..	..	..	..	B. ..	..	..	..	×	..	..
	Class Cephalopoda. Sub-Branch Tetrabranchiata. Order Nautiloidea. Sub-Order Orthochoanites.																	
W	**Nautilus peronatus** (Crick) (1) ..	×	×	×	×	×	..	..	×	×	2	b.c.L.o.r.t.	×	×	..	..	×	..
	,, *sinuatus* (Sowerby) (?) ..	..	×	..	..	..	..	..	..	..	1	a.c.o. ..	..	..	..	..	..	..
	,, spp.	×	×	..	..	..	..	..	..	..	..	a. ..	..	..	..	×	×	×

	Order Ammonoidea.																	
	Ammonites lautus	..	..	×	..	..	..	..	..	..	..	.. ..	..	..	..	..	..	×
W	,, Walcottii (Sowerby) ..	×	..	×	..	..	..	..	..	..	..	b.c.o. ..	..	..	..	×	..	..
W	,, **(Dorsetensia) Clarkei** (Crick) (2)	×	×	×	×	×	..	×	×	×	2	a.B.c.L.O., r.T.	×	×	×	..	×	..
	,, **(Dorsetensia) sp.** ..	..	..	..	..	..	..	..	×	..	..	.. ..	×	..	..	..	..	..
W	,, (Dumortieria) Moorei (Lycett)	×	×	×	..	..	..	..	..	..	..	a.B.c.l.o.	..	..	..	×	..	..
	,, (Macrocephalites) macrocephalus (3) (Schlot)	×	×	×	×	..	..	..	..	..	..	B.c. ..	..	..	..	×	..	..
	,, (Macrocephalites) sp. ..	..	..	×	..	..	..	..	..	..	..	.. ..	..	..	..	×	..	..
	,, **(Perisphinctes) Championensis** (Crick)	..	..	×	×	×	..	..	..	×	2	L.o.Q.r.t.	×	..	×	..	×	..
	,, (Perisphinctes) robiginosus (Crick)	..	..	..	..	..	..	..	..	..	2	L.o.r. ..	..	..	..	..	×	..
W	,, **(Sphæroceras) semiornatus** (4) (Crick)	..	..	..	×	..	..	..	..	..	2	B.c.L.o.r. T.	×	..	..	×	×	..
	,, (Sphæroceras) (?) Woodwardi (Crick)	..	..	..	..	..	..	..	..	..	2	L.o.r. ..	..	..	..	..	×	..
	,, (Stephanoceras) Australis (Crick) ,, (Normannites) Australis (Crick) (*fide* Chapman)	..	×	×	..	×	..	..	..	×	2	L.o.q.r.	..	×	×	×	×	..
	,, (Normannites) sp. ..	×	..	..	..	..	..	..	..	..	2	L. ..	..	..	..	..	×	..
	,, spp.	×	×	..	×	×	..	×	..	×	..	b. ..	×	..	..	×	..	..
	Sub-Class Dibranchiata. Sub-Order Belemnoidea.																	
W	**Belemnites canaliculatus** (Schl.) ..	×	×	×	..	..	..	×	..	×	..	a.B.c.o.	×	..	..	×	..	..
	,, **c.f. canaliculatus** (Schl.) ..	..	..	×	..	..	..	..	..	×	..	a. ..	×	..	×	..	..	..
(?)	,, **Canhami** (Tate)	..	..	..	..	..	..	..	..	..	2	.. ..	×	..	..	..	..	..
	,, **sp.**	..	..	×	×	×	×	..	×	×	2, 3	a.L.o.r.	×	×	..	..	×	..

(1.) This is the N. semistriatus of Moore; *vide* Crick. Geol: Mag., Dec. IV., Vol. 1 (1894), p. 387. (2.) This is the A. radians of Moore's paper; Crick. *op. cit.*, pp. 388–391. (3.) *Vide* Stephanoceras Australe Crick. *op. cit.* p. 391. (4.) his is the A. Brocchii of Moore's paper Crick. *op. cit.*, p. 435.

MESOZOIC—*continued.*

JURASSIC ONLY—*continued.*

	Genus and Species.	Locality.										Reference.	Exhibited.					
	Sub-Kingdom ARTHROPODA. Class Crustacea. Sub-Class Eucrustacea. Super-Order Ostracoda.	Shark Bay.	Moresby Range.	Greenough R.	Tibraddon.	Moonyoonooka.	Sandspring.	Woolanooka.	Snake Farm.	Mount Hill.	Doubtful Locs.		Geol. Surv. Museum.	Australian Museum	Victorian Museum.	Bath Museum.	British Museum.	Geol. Soc. Lond. Museum.
	Cythere corrosa var. grossepunctata (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
	,, drupacea var. fortior (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
	,, lobatula (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
	Cytheropteron australiense (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
	Loxoconcha elongata (Chapm.) ..	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
	,, jurassica (Chapm.) ..	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
	Paradoxorhyncha foveolata (Chapm.)	..	..	×	..	..	..	..	..	..	..	Q. ..	..	..	×	..	..	..
W	*Ostracoda—Species of*	..	..	..	..	..	..	..	..	..	1	b. ..	..	..	..	..	..	..

VI.—Western Australian Fossil Plants,

BY

LUDWIG GLAUERT, F.G.S.,

Field Geologist.

As explained in the general introduction the fossil flora of the State is very scanty, still it has been the cause of a good deal of discussion from time to time, as may be gathered from the Introduction and Historical Sketch in the Glossopteris Flora (1) by Mr. E. A. Newell Arber, of Cambridge University, and from several of the Bulletins issued by this Department. (2).

The Collie plant-remains were originally considered to be of Mesozoic Age, as explained by Mr. H. P. Woodward, in the Annual General Report for the year 1890, of the Government Geologist (page 40). A little later the late R. Etheridge, F.R.S., determined them as Permo-Carboniferous, basing his opinion on the specimens submitted to him for examination. In 1897, Mr. E. F. Pittman, the Government Geologist of New South Wales, classed them as Mesozoic in consequence of "Mr. R. Etheridge's (junr.), doubtful recognition of *Sagenopteris*." On the other hand, in 1898, Sir Frederick McCoy reported the determination with certainty of *Glossopteris Browniana* (Brong), and stated that the beds were of "the exact geological age of the great Coalfields of Newcastle in New South Wales." Dr. Jack, during his investigation, as Royal Commissioner, of the Collie Coal Industry, in 1904, came to the conclusion that the beds were of much later date, writing "I am at present inclined to believe that 'the Collie Coalfield will turn out to be possibly of Cretaceous Age. . . .'" (3.) In the following year Mr. F. Chapman, of Melbourne, after examining some specimens in the Collection of the National Museum, Melbourne, identified five species of *Glossopteris*, as well as the following Foraminifera whose range in time is as under :—

Name.	Range in Time.
Endothyra, sp.	Carboniferous Limestone
Valvulina plicata (Brady) ..	L and U. Carboniferous
Bulimina (?) *sp.*	Permo-Carbonif. of N.S.W., Triassic to Recent
Truncatulina Haidingeri (D'Orb)	Permo.-Carboniferous
Pulvinulina c.f. exigua (Brady)	(Genus) Lower Lias to Recent.

(1.) Catalogue of the Fossil Plants of the Glossopteris Flora in the Department of Geology, British Museum (Natural History), London 1905.
(2.) Bulletin G.S., W.A., 26, p. 58 *et. seq.*, Bull. 27, articles 1 and 2, 1907.
(3.) Report of the Royal Commission on the Collie Coal Field, 15 p. 7—1905.

Although the two doubtful forms may belong to more recent beds, the species determined with certainty are typically Carboniferous, the whole series " point in a general way to the Palæozoic (Permo-Carboniferous) Age of the series in which they were found." Since that time, no conflicting evidence has come to hand, so that in spite of the peculiar lithological character of the beds there seems little if any doubt about the age of the Collie Coal Seams, and their associated fossils. (1).

Though the known Palæozoic flora of the State is scanty, that obtained up to the present from the Mesozoic beds is much more so. Before the specimens described by Mr. Newell Arber in this Bulletin were found, the discoveries were limited to badly-preserved fossil wood, similar to the pieces referred to by Mr. Arber on page 27, so that the determination of even the one species, *Otozamites Feistmanteli* (Zigno), is a great advancement, one which suggests that the locality near Mingenew may yield a good harvest at some future time when it is possible to make a prolonged and systematic search in the beds, whence these few plants were obtained by Mr. W. D. Campbell, in 1908.

References.—The plan adopted in the list of the fossil fauna is continued.

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(1) *Glossopteris* is a genus of ferns which is looked upon as being not younger than Triassic or Rhœtic, E. A. Newell Arber, *loc. cit.*

WESTERN AUSTRALIAN FOSSIL PLANTS.

(*a*.) PALÆOZOIC.

The following plants are recorded from Carboniferous and Permo-Carboniferous Strata :—

Genus and Species.	Locality.	Reference.	Exhibited.		
			Geol. Surv. Museum.	Aus-tralian Museum.	Victorian. Museum.
Calamites sp.	Kimberley	e.	..	..	..
Chondrites (?) **sp.**	Minilya R.	n.P.u.	×	..	..
Cyperites (?) **sp.**	Kimberley	I.	×	..	..
Glossopteris Browniana (Brong.)	Gascoyne R. and Collie Coal-field	n.r.S.	×	..	×
,, **angustifolia** (Brong.)	Collie Coalfield	n.r.S.	×	..	×
,, communis (Feistm.) *	Do.	n.r.S.	..	..	×
,, **gangamopteroides** (Feistm.)	Do.	n.r.S.	×	..	×
,, Indica (Brong.) *	Do.	n.r.S.	..	..	×
,, **spp. ind.**	Do.	n.r.s.	×	×	..
,, (**Vertebraria**) **sp.**	Collie Coalfield and Bulls Brook	n.r.S.	×	..	×
Lepidodendron sp.	Kimberley	e.i.r.	×	..	..
,, (**Knorria condition**) **sp.**	Do.	e.i.	×	..	..
,, (*Sagenaria*) *sp.*	Do.	e.	..	..	..
Lepidophyllum (?) *sp.*	Do.	e.	..	..	..
Lepidostrobus sp.	Do.	e.i.	..	..	..
Rhizomopteris (?) sp.	Collie Coalfield	S.	..	..	×
Sigillaria sp.	Kimberley	e.	..	..	..
Stigmaria sp.	Do.	e.r.	..	..	..
Noeggerathia (?) **sp.**	Collie Coalfield	r.s.	×	..	..

* Some authorities consider these two species to be identical. *Vide* Bulletin 27, pp. 12 and 13.

WESTERN AUSTRALIAN FOSSIL PLANTS—*continued.*

(*b.*) MESOZOIC.

The following plants are recorded from Jurassic Strata :—

Genus and Species.	Locality.	Reference.	Exhibited.		
			Geol. Surv. Museum.		
c.f. **Araucaria peregrina** (Kurr.)	3 m. South of Mingenew	t.	×	..	..
c.f. **Cunninghamites Australis** (Ten. Woods)	Do.	t.	×	..	..
c.f. **Pagiophyllum sp.**	Do.	t.	×	..	..
Otozamites Feistmanteli (Zigno)	Do.	t.u.	×	..	..
,, **sp.**	Mount Hill	u.	×	..	..
Fern fronds	3m. South of Mingenew	t.u.	×	..	..
Seed Vessels	Do.	t.u.	×	..	..
c.f. Williamsonia pecten (Phill.) *	Point Torment near Derby	..	×	..	..

* This is the first indication of the presence of Mesozoic strata in the Kimberley Division of the State.

VII.—New Fossils from the Napier Range, Kimberley,

BY

LUDWIG GLAUERT, F.G.S.,

Field Geologist.

During Mr. H. P. Woodward's visit to the Kimberley area in the year 1906, with a view of reporting on the Narlarla Hills, he had an opportunity of collecting a few fossils which have proved to be of great interest and importance, on account of the light which they shed upon the exact age of large tracts of country, and the bearing they have on the Geological Maps of the district, as interpreted by the late E. T. Hardman and Dr. R. Logan Jack. These two authorities considered the Napier Range to consist of Carboniferous beds only, with a bed of conglomerate at the base of the series. This "basement conglomerate" mainly consists of fragments of the older igneous and metamorphic rocks and appear to greatly resemble the "Basement Conglomerate" so often found under the Carboniferous Limestone, etc., in the British Isles, and considered to be of Carboniferous age.

From Mr. Woodward's results, however, it is evident that the conglomerate is truly Devonian, and that most likely in Western Australia it is the basal bed of the Devonian strata, and not of the Carboniferous.

Perhaps at this juncture it is advisable to quote Mr. Woodward's account of the beds as exposed in the Barker Gorge—a gorge cut through the Range by the Barker River in its course from the King Leopold Ranges to the Meda River and the Sea. Mr. Woodward writes as follows :—

> "The Napier Range consists of a series of crystalline limestone beds which strike in a north-westerly and south-easterly direction and dip at an angle which varies from 12 to 23 degrees to the south-westward. These beds present the usual character of the Palæozoic limestone of this State, viz., they consist of a series of thick solid crystalline beds of a grey colour interbedded with soft calcareous bands of a more argillaceous character, whilst the basement beds consist of calcareous breccia and conglomerate, the enclosures in which consist of masses, fragments, boulders or pebbles of schist, granite, and quartz derived directly from the crystalline schists, granites, and greenstones upon which they rest. This range, which rises to an elevation in places to 400 feet above the adjoining plain from which it rises abruptly, is

fairly riddled with caverns and has been intersected at one or two points by watercourses which have cut deep gorges through it, varying from 2 to 4 miles in length.

"In the gorge formed by the Barker River (142° 43′ E. long., 170° 16′ S. lat.), one of the tributaries of the Meda River, a fine section of these limestones is exposed dipping beneath the sandstones and shales which form the plain to the south-westward and have provisionally been classed as Upper Carboniferous. *

"Some little time was spent in searching for fossils in the softer beds above-mentioned, but without success. Just before my departure, however, some red coloured limestones were discovered in a small branch gully upon the south side of the Gorge and near the base of the series, which proved to be full of organic remains. Owing to their hardness, however, forms could only be identified upon the weathered surfaces, and since my party had already started I was only able to carry away as many as my pockets would hold."

These specimens were in due course forwarded to the British Museum, London, for identification by the officers on the staff of that Institution. On the 16th of March, 1908, Dr. Henry Woodward, F.R.S., the late Keeper of the Geological Department, returned the fossils, writing as follows in his covering letter of the same date :—

"I now return the specimens, with such information as I have been able to collect concerning them."

[6923.] (F327) 1.—The fish bone with "berry"-like sculpturing upon its surface must be referred to a large Devonian fish (new to science) allied to *Coccosteus*, but the specimen is not sufficient to determine accurately its relation to the skeleton.

[6928.] (F334) 2.—Tail of a Trilobite genus—*Proetus*, a new species.

[6928A.] (F335) 3.—Head of a Trilobite (part of same specimen) (?) and counterpart of tail.

[6926.] (F331) 4.—Crinoid stem (?) also remains of a gasteropod shell seen in section, *Loxonema sp.* (?)

[6929.] (F336) 5.—Imperfect specimen of a gasteropod, in white spar. *Euomphalus sp.* (?).

[6925.] (F329) 7.—A Rhynchonella, near to *R.* (*Uncinulus*) *Timorensis* Beyr. and *Pachypora sp.* on same block.

[6924.] (F328) 10.—A coral, *Phillipsastræa sp.*

[6925A.] (F330) 11.—*Pachypora sp.* (*see* **[6925]**, above).

[6927A.] (F333) 13.—Two crinoidal stems (not determined).

[6927.] (F332) 14.—A. Crinoidal arm } on same block.
B. *Goniatites sp.* }

* *See* Hardman's 1884 Report, pages 9 and 20.

> "I am sorry to offer you such poor determinations, but (although the rock is full of fragments) the specimens are very imperfect and obscure, the small Brachiopod, the pygidium (tail) of the Trilobite and the coral, *Phillipsastræa*, being the only clearly preserved ones. The facies of the fauna, especially the fish plate *Coccosteus* (*c.f.*), is undoubtedly Devonian."

On an enclosed slip Dr. Woodward writes:

> "The matrix and the fossils agree closely with the Devonian of Adorf in Waldeck, Germany, *see* E. Halzapfel, 'Die Goniatiten-Kalke von Adorf in Waldeck,' Palæontographica Bd. XXVIII., Lief. VI., Jan., 1882, pp. 225–262, pls. XLIV., (I.), XLIX., (VI)."

Two other enclosures are of interest, being letters from Dr. A. Smith Woodward concerning the fish remains. On the 25th of March, 1907, this authority writes:

> "The Western Australian Fossil looks remarkably like a piece of a large Devonian Coccostean, hitherto unknown in the Australian Region, but it is not good enough for exact determination. I will try a fragment under the microscope to discover whether the tissue is true bone."

Again, on the 25th of the following month the same gentleman gives the following information:—

> "I have compared this bone again and am sorry it is too imperfect to determine from its shape its true nature. The texture and the ornament agree more closely with those of Coccostean fishes than with any other. I therefore think the new fossil belongs to one of the armoured Devonian fishes such as have not hitherto been satisfactorily determined in Australia."

It will be thus seen that competent opinion is agreed upon the age of these red limestones being Devonian, in fact, not the slightest suspicion is expressed by Dr. Woodward in his letter as nothing could be more definite than his assertion.

If we regard such genus represented separately we notice that the facies is as follows (1):—

Genus.	Distribution in Time.
1. *Pachypora sp.*	Silurian to Devonian.
2. *Phillipsastræa sp.* ..	Devonian and Carboniferous.
3. *Rhynchonella* (*Uncinulus*)	Devonian chiefly.
4. *Euomphalus sp.* ..	Silur. Dev. Carbonif., Perm., Trias.
5. *Loxonema sp.*	Silur. Dev. Carbonif. Perm. Trias.
6. *Goniatites* (*Glyphioceras*)	Devonian and Carboniferous.
7. *c.f.* *Coccosteus* ..	(Coccostean fish) Devonian only.

On analysis it is apparent that the facies is most decidedly Devonian. We have one form, the Coccostean fish, which is absolutely confined to that age; one genus, *Pachypora*, which becomes extinct before the Carboniferous, a coral, *Phillipsastræa*, which,

(1.) *Fide* Zittel.

though present in Carboniferous rocks is most plentiful in the Devonian, and a cephalopod, *Goniatites* (*Glyphioceras*) that is equally abundant in Devonian and Carboniferous times. *Euomphalus* and *Loxonema* though at their prime in the Carboniferous are plentiful in the Upper marine Devonian. The only possible exception is the *Rhychonella* (*Uncinulus*) *c.f. Timorensis*, but this loses its weight when we remember that the specimen is *not identical* with the Timor form but that it bears a *great resemblance* to that shell, and bear in mind that some of the Brachiopod shells living to-day in the seas off the coast of Australia, Great Britain, etc., can scarcely be distinguished from their ancestors found in some of the oldest fossiliferous beds of Europe and America.

The existence of the true Devonian beds in Western Australia was formerly more or less a matter of conjecture, as the true Devonian fossils were few and very far between, so that this confirmatory evidence from the Napier Range is very opportune, and reflects credit upon the authorities who determined the presence of Devonian beds when undertaking the pioneer geological work in this vast State twenty years ago.

VIII.—The Geological Age and Organic Remains of the Gingin "Chalk,"

BY

LUDWIG GLAUERT, F.G.S.,

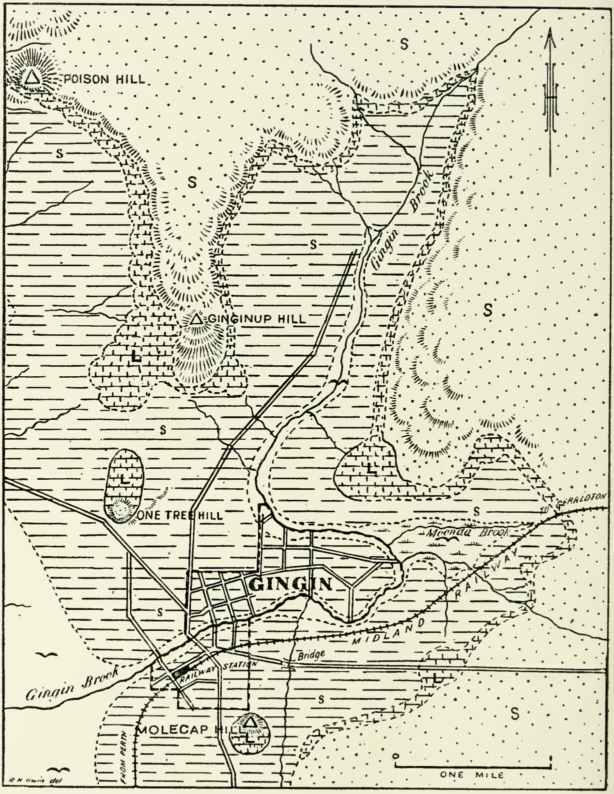
Field Geologist.

The name "Gingin Chalk" has been given to a thin bed of white chalky limestone that is exposed in various places in the vicinity of Gingin, * the best known being the summit of One Tree Hill, where the stone has been quarried for the manufacture of lime and cement.

The exposure shows a white chalk without flints, about 15 feet in thickness, which passes downwards into a greenish glauconitic marl and below that into a clayey rock. The character of the beds is not at all constant, as the most easterly patches consist mainly of clay (block 127, South of Moonda Brook), the amount of limestone increasing to the westwards. In all the localities the presence of the beds can be determined by the exceedingly rich black clayey soil due to the weathering and disintegration of the rock, a soil which bears rich crops of grass or cereals, remarkable even in that good Agricultural District. The knolls on the flanks of Ginginup, or Sunday Hill, and on both banks of the Moonda Brook, as well as the outliers forming the crowns of One Tree Hill and Molecap Hill, are recognisable in this way, but where the beds are situated in an escarpment, or hill side, the debris from the overlying ferruginous sandstone beds tends to obliterate this feature, thus rendering the tracing of the beds a matter of some difficulty. The largest exposure is on the western and southern sides of Ginginup, or Sunday Hill, and is several square miles in extent. As is usually the case in this district no good exposures or escarpments are visible, so that it is difficult to ascertain the dip and strike of the beds. Several small masses of limestone, which seems to be *in situ*, were noticed and, though the dip varied both in direction and amount, the general trend of the strata seemed to be horizontal. The rich black soil studded with fragments of limestone of all sizes was very conspicuous in the ploughed land and in the banks of the small gullies.

* *Vide* Lands Department 80 chain Lithographs 28 and 31.

FIG. 4.



EXPLANATION

ALLUVIUM .... ~

FERRUGINOUS SANDSTONE .... S

GINGIN "CHALK" & CLAY L

VARIEGATED CLAY (? *Shale*) .... s

Boundaries obscured by drift sand and superficial deposits.

The One Tree Hill exposure is the best example, as the position is very prominent and is also conveniently situated. It has received attention from the industrial world, as for some years the "chalk" has been quarried and burnt for lime in the two draw-kilns close at hand. Although the quality seems to have been excellent, the time required for "slaking" was considered detrimental by builders and contractors, so that the industry had to be abandoned for the time being.

The quarry however, is of special interest, as it presents, we may say, the only clear section of the beds. Under a layer of soil and subsoil, averaging about 12 inches in thickness, there is a band of white, rather crumbly, limestone almost free from impurities and containing no fossils; measuring about 18 inches. This is followed by a "chalk" which becomes richer in alumina and silica as it is followed downwards, till finally at about 15 feet below the purer limestone it resembles a greenish glauconitic clay.

The large Lamellibranchs are found in the upper portion of the main bed, and seem rare or entirely absent in the lower strata, where dwarfed Corals, Brachiopods, Lamellibranchs and Gastropods, as well as numerous Serpulæ and Echinoderm spines represent the remains of the animal life of the day, which appears to have been very adversely influenced by the muddy, if not turbid, water in which the creatures were compelled to pass their existence.

The fossils which were obtained during a visit (June, 1909), have not yet been subjected to careful examination owing to the lack of time, still, amongst the new records are Corals and Gastropods, as well as a species of Serpula very different from the involute form so plentifully represented in all the collections of Gingin fossils.

In this locality the beds have a slight northerly dip of eight or nine degrees.

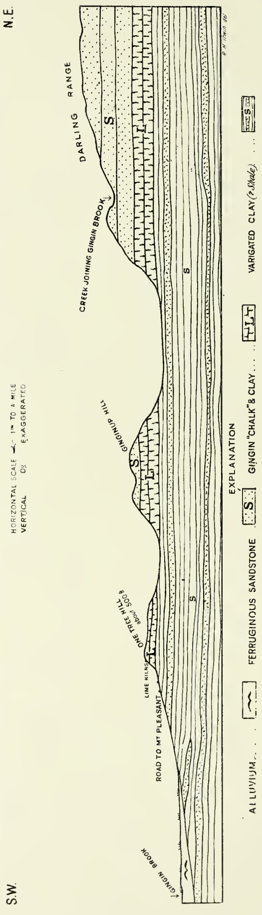
The bow formed by the Gingin Brook before being joined by the Moonda, partly encloses another mass that has similar character and rivals the One Tree Hill outcrop in extent.

At the eastern edge of the patch on the Bindoon Road, two miles from Gingin Railway Station, an exposure in a gully shows the greenish-yellow glauconitic clay with two or three thin layers of limestone. Lastly, on the hillside east of Moonda, the clay is noticed in the channel of a gully without any trace of the limestone.

The exact relationship between the "chalk" and the overlying ferruginous sandstone and the underlying variegated clay or shale could not be definitely established as no section was to be seen, still, the general character of the beds in the district suggests the absence of any unconformity, although it must be noted that a bed of sandstone below the lime-kilns on One Tree Hill had an apparent dip of eight degrees south, which may be due to settling after the removal of the underlying clay by the rain, etc.

Fig. 5.

GENERALISED SECTION FROM GINGIN BROOK THROUGH ONE TREE HILL TO GINGINUP HILL AND THE DARLING RANGE



The following section shows the probable course and distribution of the various beds proceeding from the flats below Gingin through One Tree Hill to Ginginup and the Darling Range in a N.N.W. direction.

The presence of a bed of chalk in Western Australia has been known for over 50 years. Gregory's map of 1860 * shows two patches of "chalk and sandstones containing flints and Cretaceous fossils"; they are situated at Gin Gin and Yatheroo, and measure, roughly speaking, eight by five miles and six by three miles respectively. This map was exhibited at a meeting of the Geological Society to illustrate a paper by F. T. Gregory on the Geology of the Colony, and was subsequently printed. † In the paper Gregory states:

> "The Cretaceous (?) are the most extensively developed of the sedimentary rocks of Western Australia, and are almost exclusively silicious in character, *containing only a few beds of chalk* of very inferior quality." "They abound however, more in fossils than the Carboniferous do, and, with the exception of the recent coast limestones, more so than any other formation. Flints are rarely found in them." "The bed of the Greenough River is the best spot for procuring specimens, although a few are found in the chalk hills near Gin Gin (Echinoderm spines, etc.)"

* General outlines of the Geology of Western Australia, compiled by F. T. Gregory, F.R.G.S.—1860. Published in 1861 by John Arrowsmith of London.

† On the Geology of a part of Western Australia. Quart. Jour. Geol. Soc. (London), 1861, Vol. XVI. pp. 475–483.

These remarks are of interest, as they show that Gregory considered the Gingin Chalk to be Cretaceous in age, and very closely connected with the Jurassic Beds of the Greenough River. That these latter are thought to be Cretaceous is confirmed, firstly by his map (1), and secondly by the fossils which he presented to the Geological Society being classed by him as Cretaceous (?).

Mr. C. Moore examined these fossils and found them to consist

> " of a single cast of *Trigonia Moorei*, Lycett, and a very much worn *Pecten*, of uncertain species, both evidently of Oolitic age. They were accompanied by a *Ventriculites* in flint, a portion of a chalk Ammonite, and also by a considerable number of specimens of the age of the Carboniferous Limestone."

In the paper on " Australian Mesozoic Geology and Palæontology," (2) from which the above quotation is taken, Mr. Moore also refers to the " siliceous cast of a *Micraster* from the Chalk " in a set of fossils forwarded by Mr. Shenton.

Mr. H. Y. L. Brown in his general Report of 1873, writes as follows on page 13:—

> " The white chalky limestone of Gin Gin, Yatheroo, and Dandarragan, which outcrops from beneath the sandy soil of these localities in patches, most likely is also of Mesozoic age. As yet, owing to the surface accumulations of sand, etc., which hides it from view, no sections are to be seen which show whether it is over, or underlies the ferruginous rocks of the District."

A Geological Map of Western Australia * was issued to show the work done from August 1870, to June, 1872, by Mr. H. Y. L. Brown, who was the Government Geologist during that period. Upon this map the three patches of " white limestone " referred to above are shown to be approximately of equal area, measuring about seven miles by six miles.

In the year 1903, Mr. E. S. Simpson paid a short visit to the locality and examined some of the outcrops. In the quarry on One Tree Hill he obtained some fossils which were forwarded to Mr. R. Etheridge, Curator of the Australian Museum, for examination.

His conclusions upon these fragmentary and badly preserved specimens are given on page 38 of Bulletin No. 27 †, and are now quoted in full.

Fossils from Chalk Pit One Tree Hill, Gingin.

[**5551.**]—Chert ? semi-stalactitic.

[**5552.**]—*Ostrea*, allied to *O. vesicularis*, Lamk.
(F238)

(1.) In a section taken from this Map as shown as fig, 2, on page 477 of Vol. XVI. (1861) of the Quarterly Journal of the Geological Society, the Carboniferous beds of the Kennedy Range are classed as Cretaceous (?), the true relationship of the beds is shown by Mr. A. Gibb-Maitland the Government Geologist in fig. 6, page 15 of Bulletin No. 33—1909.

(2.) Quarterly Journal of the Geol. Soc. London, Volume XXVI., page 227, 1870.

(*) Printed by H. G. deGruchy, & Co. Melbourne—no date.

† Palæontological Contribution to the Geology of Western Australia, II.—Bulletin No. 27—Perth, 1907.

[5553.]—Crushed Brachiopod, possibly a *Magellanic*.
(F239)

[5554.]—*Terebratulina* (?) This is quite distinct from any
(F240) other described Australian Tertiary Brichiopod, and if examples can be obtained, showing the interior, is worthy of description.

[5555.]—*Serpula*, quite undescribed as an Australian form. It
(F241) is allied to the European Tertiary Serpula. *S. Bognoriensis*. Specimens are retained for description.

[5556.]—Spines of two species of Echinids *Phyllacanthus*,
(242) spines belonging to species of this genus have been found in the Tertiary beds of Willunga, S.A.

[5557.]—Portion of the shell of the Bivalve *Placunanomia*.
(F243) Could a more or less perfect example be procured it would be worth description.

"The fossils from One Tree Hill Chalk Pit are certainly not older than Tertiary, but the evidence is of too limited a nature to enable me to suggest any horizon within that great formation, but I suspect the deposit must be well up in the series; for the sake of a name, and until more is known, call it Upper Tertiary. The condition of the fossil is not one that lends itself to accurate determination, but the *Terebratulina* (?) *Serpula* and *Placunanomia* certainly seem to be new, and if additional specimens of the first and last can be obtained the whole are worthy of description."

It will be noticed that Mr. Etheridge remarks upon the very unsatisfactory state of the few fossils submitted to him, and there is no doubt that if the associated fossils obtained from the same quarry at various times and presented to the Western Australian Museum had been sent to him with those of the Survey collection, he would have come to very different conclusions; that is to say, he would unhesitatingly have classed them as Cretaceous.

The Palæontological Contribution to which Mr. Etheridge's determinations form an introduction, is a list and description of Gingin Chalk Foraminifera. Thirty-seven species of these small organisms are described, eight of which are practically, if not entirely, confined to Cretaceous beds in the other parts of the globe. On the other hand only four species (one of them doubtful) are peculiar to the Upper Tertiaries, whilst 27 are known to have existed in Cretaceous times.

These facts struck Mr. Chapman of the National Museum, Melbourne, for in a letter to the Government Geologist under the date of February 22nd, 1908, he writes: "Mr. Howchin's list of Foraminifera from Gingin interests me very much, and *I cannot help concluding from the evidence of that group alone, that the deposit is decidedly Cretaceous.*"

In order to place the matter more clearly, and as an assistance for future reference, these Foraminifera are given in tabular form together with their distribution in Geological Time.

	Foraminifera—Genus and Species.	Cambrian, etc.	Silurian.	Devonian.	Carboniferous.	Permian.	Triassic.	Jurassic.	Cretaceous.	Eocene.	Oligocene.	Miocene.	Pliocene.	Pleistocene and Recent.
*R.	*Miliolina oblonga* (Montagu)									—	—	—	—	—
1	*Spiroloculina* (?) *grata* (Terq.)											—	—	—
C.	,, *asperula* (Kar.)								— -			—	—	—
1	*Placopsilina vesicularis* (Brady)									- -	- -	- -	- -	—
S.	*Textularia trochus* (d'Orb.)								—	—	—	—	—	—
R.	,, *turris* (d'Orb.)								—	—	—	—	—	—
R.	,, *sagittula* (Defr.)								—	—	—	—	—	—
R.	,, *globulosa* (Ehr.)								— -	- -	- -	- -	- -	- -
C.	,, *gibbosa* (d'Orb.)				—	—	—	—	—	—	—	—	—	—
1	*Verneuilina spinulosa* (Reuss)								—	—	—	—	—	—
C.	,, *polystropha* (Reuss)								—	- -	- -	- -	- -	- -
R.	*Lagena hispida* (Reuss)							—	—	—	—	—	—	—
R.	,, *globulosa* (W. & I.)		—	—	—	—	—	—	—	—	—	—	—	—
C.	*Nodosaria consobrina* var. *emaciata* (Reuss)								—	—	—	—	—	—
S.	,, *vertebralis* (Batsch)													
S.	,, *soluta* (Reuss)								—	—	—	—	—	—
1	,, *obliqua* (Linné)					—	—	—	—	—	—	—	—	—
1	*Frondicularia intermittens* (Reuss)								—					
S.	,, *chapmani* (Perner)								—					
1	,, *gaultina* (Reuss)								—					
S.	*Flabellina interpunctata* (v.d. Marck)								—					

1 One specimen only. C. Common. R. Rare. S. Several.

	Foraminifera—Genus and Species.	Cambrian, etc.	Silurian.	Devonian.	Carboniferous.	Permian.	Triassic.	Jurassic.	Cretaceous.	Eocene.	Oligocene.	Miocene.	Pliocene.	Pleistocene and Recent.
C.	*Marginulina costata* (Batsch)						—	—	—	—	—	—	—	—
C.	*Cristellaria rotulata* (Lam.)		—	—	—	—	—	—	—	—	—	—	—	—
C.	,, *cultrata* (Mont.)							—	—	—	—	—	—	—
Sc.	,, *orbicularis* (d'Orb.)											—	—	—
M.C.	,, *acutauricularis* (F. & M.)							—	—	—	—	—	—	—
R.	,, *ovalis* (Reuss)								—					
V.C.	*Globigerina bulloides* (d'Orb.)	—	—	—	—	—	—	—	—	—	—	—	—	—
S.	,, *cretacea* (d'Orb.)								—	?	?	?	?	?
V.C.	,, *linnæana* (d'Orb.)								—	—	?	?	?	?
Sc.	*Discorbina opercularis* (d'Orb.)											—	?	—
R.	*Truncatulina lobatula* (W. & I.)				—	—	—	—	—	—	—	—	—	—
Sc.	,, *variabilis* (d'Orb.)								—	—	—	—	—	—
R.	*Rotalia Beccarii* (Linné)							—	—	—	—	—	—	—
Sc.	,, *broeckhiana* (Kar.)									—	—	—	—	—
1	,, *soldanii* (d'Orb.)										—	—	—	—
1	*Nonionina asterizans* (F. & M.)									—	—	—	—	—

C. Common. M.C. Moderately common. V.C. Very common. Sc. Scarce. 1 One specimen only. R. Rare. S. Several.

In the Geological Survey Museum there is an interesting suite of fossils which were presented to the Western Australian Museum in 1897 by Mr. W. R. Philbey ; though not in good condition, they are sufficiently well preserved to give an insight into the age of the Gingin chalk beds in which they were found. They comprise examples of various groups of animals Echinoderms, Worms, Brachiopods, Lamellibranchs, Cephalopods, and a Shark's tooth.*

Serpula sp. cf. *S.* (*V.*) *concava* (1) Sowerby [**10091**]. By far the most plentiful are splendidly preserved *Serpulæ*, animals which seem to have found congenial surroundings in that part of the Ocean where this bed of Chalk was forming. The numerous specimens plainly show that there was a certain amount of variation in the shape which the coiled tube assumed. One form may be described as discoid, involute, with a portion of straight tube ; almost flat on one side and concave on the other, the innermost whorl (s) often wanting ; being the chief point of attachment to the foreign object. (2) The form at the other extreme has one side of the involute tube more concave and the other convex, or obtusely conical. The surface of the tube shows the markings known as " lines of growth " but bears no other ornamentation ; longitudinal furrows or ridges which are to be seen on *S. Bognoriensis* (3) are entirely absent. A large umbilicus on the concave side, absent on the other (the side of attachment) owing to the manner in which the shell-matter has been deposited. Section of the tube circular both interiorly and exteriorly, the tube is thick in the older portions but thin at the natural opening, in this way differing from Sowerby's *S. tumida*. (4).

The average dimension (diameter) of the full grown individual is 16 m/m across the widest part of the involute portion, the largest I have seen, measuring $18\frac{1}{2}$ m/m. The number of whorls is four or five.

I have compared the specimens with the figures and descriptions in the few works of reference to which I have access, and find that Sowerby's *V. concava* is the form most nearly approached by the Gingin shells. Sowerby describes his species, which is from the Greensand of Dilton near Westbury, England, as " discoid, involute, concave on one side, the last whorl but slightly attached." Below he states, " this is almost wholly involute with but a small portion of straight tube, the surface is nearly smooth and even, the involute part is concave on one side only, the other being flat.

* These fossils have been forwarded to Mr. R. Etheridge of the Australian Museum for detailed examination.

(1.) Sowerby's Min. Conch. (*Vermicularia cancava*), Volume I., page 125, pl. 57, figs. 1–5.

(2.) In the quarry on One Tree Hill, Gingin, I have seen specimens of the Serpula attached to fragments of shell, but as soon as they were handled they became disunited. The scars are generally seen on the flat or convex side of the involute tube.

(3.) Somerby's Min. Conch., Volume VI., page 194, pl. 596, figs. 1–3.

(4.) Sowerby's Min. Conch., Vol. I., page 125, pl. 596, fig. 4.

It seldom exceeds three-fourths of an inch in diameter, with about four turns."

Sowerby's *S.* (*Vermetus*) *Bognoriensis* to which Mr. Etheridge compares the Serpula, is described: * "Spiral portion conical, sub-discoid, concave beneath, tube obscurely five sided, with a furrow above and below; the produced part cylindrical, slightly curved. The tube is more angular, and the whorls more numerous than in *V. concava,* to which it nearly approaches, but when the surface is worn it appears cylindrical."

The Gingin specimen differs to some extent from both these specimens, but seems to bear closer relations to them than any other form with which I have been able to compare it, so that it is unnecessary to refer to any other species. There are obvious differences between the Gingin Serpula and *S.* (*V.*) *concava,* such as the habit of assuming an obtusely conical form, the state of attachment of the last whorl and the thickness of the whorls, but I have no doubt that the shells are closely related.

Among the specimens collected in June, 1909, I have noticed a small Serpula [**8922**] very like Sowerby's *Serpula fluctuata* (1) from the Chalk Marl.

Echinodermata.

This group is represented by numerous spines [**10092**] of varied size and pattern; the longest measures about 43 m/m, whilst the shortest would not exceed one-third of that length. In a general way they resemble the numerous muricated Cidarid spines plentiful in the white chalk and other Cretaceous beds of Europe. Mr. Etheridge refers the spines to species of *Phyllacanthus* in his short note upon some of the Gingin remains. (†) Numerous hexagonal plates, evidently portions of the test, were obtained in June last, and have been submitted to Mr. Etheridge for examination.

Brachiopoda.

The seven Brachiopoda belong to three genera, as far as can be judged from the external characters. One specimen is large but the others are small and delicate.

The large shell [**10095**] measures 40 by 27 m/m, and bears a striking resemblance to the *Terebratula biplicata* (2) Brocchi, figured by Davidson as a variation of the species. It is possible that this shell is not from Gingin, for the chalky material filling the shell seems harder than the usual Gingin rock, and the state of preservation of the shell is different.

Two small shells [**10094**] with fine radiating costæ and concentric lines of growth upon a shell showing a marked plication, are

* Loc. cit.
† Bulletin No. 27, page 38.
(1.) Min. Conch., Vol. VI., page 228, pl. 608, fig. 5.
(2.) Monogr. Brit. Fossil Brachiopoda., Vol. I., part 2, pl. VI., figs. 19–20.

identical with [**5554**] which Mr. Etheridge has determined as a (?) *Terebratulina.* (1)

Another group [**10093**] that has a smooth shell very finely punctate, but showing concentric lines of growth and possessing a slight plication, has been referred to by Mr. Etheridge as possibly a *Magellania.* (2)

Two somewhat larger shells showing no plication have been classed provisionally with the above, under number [**10093**]. The limited number of the specimens and absence of all knowledge of the interior of the shell makes further investigation impossible.

Pelecypoda (Lamellibranchiata.)

Inoceramus spp. etc.

After the *Serpulæ* the most commonly represented shells are undoubtedly those belonging to species of *Inoceramus*, etc. [**10096**].

Almost every rock in this collection of Gingin Fossils contains fragments of the shell of this striking genus so readily distinguished by the prismatic fibres of the thick outer layer of the shell. There are also more or less perfect internal casts, occasionally with fragments of the shell adhering to them.

The general outlines of the individuals and the structure and ornamentation of the shell are good indications of the genus to which these specimens have been referred, though the umbonal region and the hinge line are missing. There are some specimens, which in a general way, resemble the *I. pernoides* from the Queensland Cretaceous, others which remind one of Sowerby's *I. mytiloides* ; McCoy's *I. Carsoni* ; D'Orbigny's *I. problematicus* or Mr. Etheridge's *I. elongatus,* all of which are referred to by Mr. Etheridge in his Palæontology of Queensland. (3) Several specimens are like *I. constrictus* (Eth. fil.) (4) in form, but all are incomplete.

There are remains, mostly fragmentary, of other Pelecypods, but they are unsatisfactory for purposes of identification, as important portions of the shell are missing.

It seems that the following genera may be represented. *Pseudavicula, Ostrea, Gryphæa, Mytilus* and possibly *Glycimeris,* and others (5.)

See [**10096**], [**10100**] and [**10103**], under which numbers are included all the Pelecypods of the collection.

(1.) Bulletin No. 27, page 38.
(2.) Loc. cit.
(3.) Jack and Etheridge Geol. & Pal. of Queensland, page 463, *et seq.* and plates.
(4.) Queensland Geol. Survey Bulletin No. 13, page 24, plates II. and III.
(5.) A careful comparison of these specimens with the numerous Lamellibranchs of the Older Tertiary of Australia, figured and described by Prof. R. Tate in the Transactions of the Royal Society of South Australia, may have important bearing upon the age and relationship of the strata.

Cephalopoda.

In determining the age of Mesozoic beds, the presence of Ammonites is of great value ; it is therefore satisfactory to be able to state that two genera are present [**10101**], [**10102**]; one of which, *Crioceras.* (?) is undoubtedly Cretaceous. The other genus is represented by numerous examples, two more or less perfect casts of a large discoid Ammonite with somewhat inflated whorls.

[**10101**.] The specimens are in a poor state of preservation, with most of the characteristics either completely obliterated or rendered very indistinct. However, there are several points that can be distinguished. The whorls have an oval section, rendered lunate through their embracing the preceding ones, and are a little higher than wide, they show no signs of a keel and seem to bear a number of ribs which pass across the venter of the shell with a slight forward curve. There are no signs of tubercles, spines or any other secondary ornamentation. The greatest width of the whorl is at the highest point of the encroachment by the preceding one. The umbilicus is very indistinct, though most probably it was not very wide and rather deep and moderately steep. Faint and irregular traces of the suture lines are to be seen which, unfortunately, are too imperfect to be of any use.

The following measurements were taken :—

	Large spn.		Small spn.
Greatest diameter of shell ..	184	..	90
Greatest width of umbilicus ..	?	..	?18
Greatest height of outer whorl	?85	..	?
Greatest width of outer whorl..	70	..	?

Another specimen consists of a small part of the suture line, most likely of an individual closely related to the above ; besides this there are two fragments of whorls and a portion of the external cast that belong to shells of the same species as the preceding.

Those remarkable Ammonities, which have received so much attention on account of the eccentricity of their shapes, are not wanting, for as already stated, we have a portion of a whorl that seems to belong to a *Crioceras* identical with, or closely allied to the *C. Australis* of Moore. (1) [**10102**].

Class Pisces. Sub-Class Selachii.

Vertebrates are also represented in the Gingin Chalk ; one of the specimens in the W.A. Museum collection consists of the tooth of one of the Lamnidæ [**10104**], This tooth, which has a length of 25 m/m, a width of $8\frac{1}{2}$ m/m at the base, and a maximum thickness of about $6\frac{1}{2}$ m/m, is *Odontaspis*-like in shape, but at the same time,

(1.) C. Moore, Australian Mesozoic Geology and Palæontology, Q.J.G.S., Vol. XXVI., 1870, p. 257, pl. XV., fig 3.

instead of the crown being curved in the usual manner, it is very faintly sigmoid as in the Mesozoic *Orthacodus.* It is evidently a remain of one of the earliest members of the great shark family, now so plentifully represented in Australian waters, and may be the earliest record. The conclusion arrived at by Mr. F. Chapman, of Melbourne, when he saw Mr. W. Howchin's list of the Foraminifera from Gingin, namely that the beds were of Cretaceous age, is confirmed by the collection of Gingin Fossils. The *Serpula, Pseudavicula, Inoceramus. Gryphæa,* and the *Ammonities* have a most decided Cretaceous aspect and, though *Pseuadvicula* and the two genera of *Ammonites* have not been recorded by collectors subsequent to 1897, as far as is known by the Department, there is no reason for doubting that they are obtained from the quarry on One Tree Hill.

INDEX TO NAMES OF PERSONS, PLACES, GENERA, SPECIES, ETC.

(Names of Genera and Species are in Italics.)

INDEX, ETC.—*continued.*

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INDEX, ETC.—*continued.*

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1909.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 37.

THE GEOLOGICAL FEATURES

OF THE

Country lying along the Route of the Proposed Transcontinental Railway in Western Australia,

BY

CHAS. G. GIBSON, B.E.,
Assistant Geologist.

Issued under the authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

WITH A GEOLOGICAL SKETCH MAP AND 21 PLATES.

PERTH:
BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

1909.

PREFATORY NOTE.

The field work on which this report is based was undertaken in connection with the survey of the proposed Transcontinental Railway.

Mr. Gibson commenced his work at Kanowna on August 27th, 1908, and remained in the field until the second of December of that year, having travelled approximately fourteen hundred miles.

The report is divided into three parts dealing respectively with the general geological features, the mineral possibilities, and the subterranean water resources.

The report is accompanied by 21 plates and a general geological map of the area dealt with.

On being submitted to the Hon. the Minister, the report was ordered to be printed for public information.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office,
Perth, 19th July, 1909.

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THE GEOLOGICAL FEATURES OF THE COUNTRY LYING ALONG THE ROUTE OF THE PROPOSED TRANSCONTINENTAL RAILWAY IN WESTERN AUSTRALIA.

Part I.—General Geological Description.

The first traverse made in connection with this work was from Kanowna along the surveyed road to the Majestic, *via* Bulong, thence to the end of the Westralian Timber Company's wood line (Kurramia) and eastward along the surveyed line of the proposed railway to Cardinia Rocks (69M).

This traverse showed the centres of Kanowna, Bulong, and Majestic to be within one main greenstone belt which was also proved to be continuous eastward almost as far as Cardinia, and was also subsequently shown to extend northwards beyond Kurnalpi probably as far as Pingin and southerly to the north end of Lake Cowan.*

The greater part of this belt is covered with extensive recent deposits (sands, loam, etc.), this being especially the case east from Bulong and along the proposed line of railway where there are large loam flats extending for miles; these being usually well timbered with salmon gum and gimlet; the nature of the rocks underlying these flats can only be determined by the character of the surface soil.

Some eight to ten miles on the south side of the line the country is more hilly and broken and the greenstones outcrop over considerable areas; it is here that the mining centres of Mt. Monger and Randells are situated.

Immediately along the line of route the only rock outcrops of any note are towards Cowarna Rocks where there are a few low greenstone ridges which, however, are not of any great extent, and appear to be almost free from the occurrence of quartz reefs. These outcrops show the country rock to be a fairly fine grained greenstone more or less foliated and similar to that usually found on the Western Australian goldfields.

The greenstones are intersected by occasional granite dykes and masses, one of the most conspicuous of these being at Cowarna Rocks, this consisting of a bare outcrop of a coarse-grained massive granite of considerable extent.

*This belt is broken here and there by small intrusions of granitic and other rocks, but these are of comparatively small extent, and are generally distinct from the great interior belt of granitic and gneissic rocks.—C.G.G.

The western boundary of this main auriferous greenstone belt lies about ten miles to the west of Cardinia and as shown on the accompanying geological sketch map runs roughly north and south; beyond this the country is granitic and non-auriferous, with the exception of a small belt lying immediately to the west and north of Cardinia, which has a width of about three miles and a length of possibly twenty, its extent being as shown on the map attached.

At Cardinia are considerable areas of bare granite rocks forming low hills and giving a splendid water catchment. The whole country about here is more hilly and broken, and in addition to the granite hills there is a series of low greenstone ridges to the west and north.

The granite is undoubtedly intrusive and newer than the greenstones, and several small fragmentary areas of the latter can be seen entirely caught up in it.

At Cardinia water is obtainable in numerous small holes in the granite and also from a soak at the foot of the rocks. The surface holes only last for a few weeks after rain, but there is a fairly good supply in the soak, and though not permanent it can be relied on for the greater part of the year provided the season has been a fairly good one and the water is not drawn upon too heavily.

From Cardinia Northwards.

From Cardinia a traverse was made northwards as shown on the map, for a distance of fifty or sixty miles for the purpose of examining the country in that direction.

For the first couple of miles low broken granite ridges were passed over—greenstone country lying a short distance to the west; after this the greenstone belt was entered upon and crossed in about three miles. This belt appears to run in a north-easterly direction for some fifteen miles; where crossed it consists of alternating low ridges and salt-bush flats, the country rock being a fine-grained foliated and schistose amphibolite, the trend of the foliations being roughly north and south. Quartz reefs are fairly plentiful throughout and some of them are of considerable size and extent; they have received some little attention from the prospector but nothing seems to have been done in a systematic way.

After crossing this greenstone belt the granitic area was again entered on, the country being flat and covered with extensive beds of recent deposits (sands, loam, etc.); up to a point some twelve miles north from Cardinia these flats for the most part support a good growth of salmon gum and salt bush, but beyond this point the timber is mostly mulga with patches of stunted gum and spinifex.

At Beerie, on the west end of Lake Roe, there is a small patch of bare massive granite rocks and at Yindi, some six or seven miles farther north a considerable extent of similar rocks prevails, these being the only two localities where outcrops of any extent were noted.

At these latter rocks (Yindi) there are several good rock water holes and also a couple of shallow soak wells. The rock-holes do not last very long but the soaks are said to be fairly permanent. At Beerie there is a small rock-hole of an estimated capacity of about one hundred gallons.

Soon after passing Yindi greenstone country was again entered on, this being portion of the main Kurnalpi, etc., belt, the eastern edge of which lies a few miles to the west of the line followed and at this point swings out considerably to the east, as shown on the plan herewith.

Where first met with there is a considerable extent of hilly country in this belt, some of the hills rising to a considerable height, *e.g.*, Mt. Quinn, Mt. Charles, Mt. Hunt, etc. This belt of hilly country can be seen running southerly for some miles, Mt. Charnleigh being apparently its southern limit. The rocks forming the hills are fine-grained greenstone of the usual type. Near the main body of granite they are intersected by numerous granitic dykes which are evidently merely offshoots from the main body. Quartz reefs are few and far between and the belt just here is not a promising looking one for the prospector.

After leaving the hills, which only run northerly for a couple of miles, extensive mulga flats are met with which extend in a northerly direction for twenty to thirty miles but are broken here and there by low greenstone ridges.

Lying about twenty-five miles to the north of Yindi is a long narrow salt lake running east and west and apparently draining to the east; this is undoubtedly part of the Mulgabbie series of salt lakes and is probably also continuous with that long narrow lake bed marked on the departmental maps as the Ponton River.

Along the south side of this lake and distant three to six miles from it are a series of low greenstone hills, many of them being covered with a thin capping of ironstone rubble. Through one of these hills which was examined, near the eastern edge of the belt, and possibly also through others, runs a large laminated quartz-hematite lode similar to those found farther north on the North Coolgardie and Mt. Margaret Goldfields. This was the only one of these lodes noted and it is probably the extreme southern limit of the well-marked Edjudina series.*

Approaching their eastern junction with the granite again the greenstones are intersected by dykes and masses of granitic rocks, some of these being of considerable extent; they are apparently all merely offshoots from the main mass to the east.

Although the greater portion of the greenstone belt is covered by extensive beds of recent deposits there are, however, considerable areas over which the rocks outcrop, this being especially the case northwards from Yindi towards the lake previously mentioned. These rocks are for the most part slightly schistose, the foliations being

* See Bulletin XI., G.S.W.A.

roughly north and south. No quartz reefs of any great size were noted but this is not to say that such do not occur; small reefs and leaders are fairly plentiful and although the district has been "run over" by prospectors, it is in my opinion sufficiently promising to warrant further attention from them.

On the return journey to Cardinia the route followed was entirely over granite country, most of it being flat and covered with extensive areas of loose sandy soil, the rocks only outcropping here and there as small isolated patches and being usually very much decomposed and weathered.

By far the greater part of this country is covered with a dense growth of mulga which can be seen extending easterly for a number of miles, gradually giving place to the interminable mallee and spinifex sand plains of the interior.

From Cardinia Southwards.

For the first two or three miles in this direction broken granite and greenstone country was passed over, the track following close to the junction of the two formations; after about three miles the main granite belt was properly entered on and was found to extend unbrokenly over the whole of the country traversed.

From Cardinia the country is, after the first mile or so, mostly loam flats to Erayinia, these being timbered with good salmon gum. On the rising ground around Erayinia the timber is chiefly mulga, but the salmon gum flats can be seen extending westerly for a good many miles.

At Erayinia the granite outcrops over a considerable area in the form of one large and several small round-topped hills; the rock is similar to that at Cardinia, being massive and fairly coarse-grained and very little weathered.

There are several small rock-holes in the granite in which a supply of water can be got after rains, but they cannot be relied on for any length of time.

Some seven miles south-south-east from Erayinia is a second small outcrop of granite in the form of a small patch of flat bare rocks a couple of acres in extent; which is practically the only granite outcrop of any importance noted, the bulk of the country being covered with a considerable thickness of loose sandy soil.

From Erayinia to some two miles beyond this second patch of rocks the country is flat and mostly timbered with stunted mulga; beyond this latter point mallee and spinifex covered sand plains and ridges come in and are then continuous southerly as far as my traverse went and as far southerly and easterly beyond this as could be seen with powerful field glasses. A few miles to the west the country is slightly better as the spinifex dies out and the timber improves somewhat, consisting of mixed salmon gum, gimlet, and giant mallee.

Some ten miles south-south-east from Erayinia are a couple of small salt lakes which are probably more or less continuous with the

well-marked series met with some twenty miles farther south. This latter series consists of a number of lakes, from a few chains up to half a mile in width, all more or less connected—the separating country being usually drift sand—and having a general trend to the south-west, the drainage also being in this direction; these lakes are evidently continuous into Lake Cowan, and they form the main drainage channel for the whole of this district.

Along the western side of one of the lakes at a point about eighteen miles south of Erayinia the greenstones were again noted. This is evidently the eastern edge of the main belt. The actual junction between them and the granite cannot be followed owing to the covering of recent deposits but it appears to run here about north and south.

The greenstones can be seen outcropping along the western side of the lake for a distance of a couple of miles; they are very much weathered and are highly foliated, the foliations running slightly west of north and east of south. Several quartz reefs of considerable size were noted in them; these are of white barren looking quartz, and as far as could be tested were devoid of gold; they run about north-north-west and south-south-east and are fairly persistent in their strike.

A short distance westward from the lakes the country is again all covered with recent deposits and no outcrops are visible.

From Cardinia Eastward to the 102-Mile.

The whole of the country between these two points is granitic and as usual is mostly flat and covered with the usual loose sandy soil. At Jumannia and a few miles to the west of it are small patches of bare granite rocks, which are the only outcrops of any note until about the 101-Mile peg is reached when a few low granite ridges are met with; these extend over a width of about a mile and run northerly for some distance.

Northwards from the 102-Mile.

A traverse was made from the 102-Mile in a northerly direction as shown on the map. The result of this was to prove that the country in this direction was all granitic, practically the whole of it being covered with loose sand and clothed with dense mallee and spinifex, with the exception of a small area crossed on the return journey and extending ten or a dozen miles north of the 123-Mile peg on the surveyed line.

Starting north from the 102-Mile the country for the first few miles is flat and timbered with stunted gum; after this it becomes somewhat undulating, consisting of alternating hollows and long low ridges, the whole being covered with dense mallee and spinifex. The general trend of the valleys is slightly north of east and the drainage from them appears to be in this direction.

This class of country was continuous to the Ponton River and east and west of the route followed as far as could be seen.

The Ponton River, as it is called on the departmental maps, is a long narrow salt lake, or chain of lakes, draining to the south-east; where crossed it was from three to four chains in width, which is apparently about its average size. The course of these lakes is along a wide deep well-defined valley and they probably mark the remains of what was once a very fair-sized river flowing in tertiary times into the sea which then covered that portion of the country now occupied by the Eucla Limestone Tableland. It is probable also that other series of lakes. *e.g.*, those near Buninginia and Newman's Rocks, as well as Lakes Cowan and Lefroy, were connected with the sea at a similar geological period; Lake Cowan undoubtedly at that time formed a large tidal estuary, as the discovery of Tertiary beach remains and sponge spicules in the so-called deep lead at the Princess Royal, Norseman, proves.

The drifting sand hills of the interior are gradually encroaching on the old bed of the Ponton and it is only a matter of a comparatively few years until it is completely obliterated. At the present time it is marked west and north of the point where crossed by a series of narrow salt lakes, connected by a sandy watercourse which could be seen trending north-westerly for many miles and which are probably continuous with the Mulgabbie series of lakes; south-easterly it gradually lapses its lake-like nature and becomes merely a sandy watercourse which varies from a half to three chains in width. In this direction it runs for about a hundred miles before dying out on the plains and for the latter part of its course is known, and is shown on the departmental maps, as Goddard's Creek.

A few miles on the north side of the Ponton along the route followed is some very high country which however is not conspicuous owing to the fact that most of the surrounding country also lies at a considerable elevation being 1,400 to 1,500 feet above sea level and several hundred feet higher than the country to the south along the surveyed line. There are several outcrops of bare granite rocks over this high country but they are of no great extent, most of the country being covered with a considerable thickness of loose sandy soil. There is a small rock-hole holding about 100 gallons from which water can at times be obtained on one of these outcrops some three miles or so north of the Ponton, this being the only water noted. A large amount of "narrow-leaf" poison bush was noted round these granite rocks; other localities where it was noted in any quantities were Queen Victoria Spring, and here and there, along the banks of Goddard's Creek; it was also noted on the coast near Twilight Cove, long. 126 E.

From the highest point from which a general view could be obtained, the country as far as could be seen with field glasses consisted of alternating low ridges and valleys all covered with a dense growth of mallee and spinifex.

Along the route followed southerly back to the survey line at a point some two miles or so south of the Ponton River are a few small outcrops of weathered granite and several small weathered granite "breakaways," which were the only rock outcrops seen on the journey south.

Sand plains and ridges covered with dense mallee and spinifex continue unbrokenly for some fourteen miles south from the Ponton; beyond this point and extending to the survey line are extensive flats covered with scattered salmon gum and gimlet interspersed with patches of mallee and spinifex, which class of country extends back westerly to the 102-Mile peg (*i.e.,* from the 123-Mile peg).

From the 104-Mile to Buninginia and Goddard's Creek.

For the first half dozen miles the country consists of salmon gum, gimlet, and salt and blue bush flats after which there are three miles or so of mallee and spinifex; at the end of this and about nine miles from the line are several small low ridges with outcrops of weathered granite, and one small isolated flat-topped hill. This hill is capped with six to ten feet of vitreous quartzite, this being the result of the decomposition of the underlying granite, and similar to that found as hill cappings on the Murchison Goldfield. Round this hill are salt bush and grass flats which extend south-easterly for several miles; patches of salmon gum also occur along the edges of these flats.

About four miles south-easterly from the flat-topped hill are salmon gum, gimlet, and salt bush flats which extend for some six miles when they give place once more to mallee and spinifex country, which is then continuous from west round through south to east as far as the eye can reach.

At Eudarie, some 20 miles south-easterly from the 105-Mile peg, are several fair-sized outcrops of bare massive granite, these being several acres in extent. On the largest of them is a rock-hole holding after rains some 200 gallons of water and there is also a small soak at the foot of the rock but the supply is not permanent.

There is a small patch of good country immediately around these rocks but beyond this the mallee and spinifex is continuous as far as can be seen.

Between Eudarie and Buninginia (18 miles) the country is all mallee and spinifex with occasional patches of stunted gums. Some five miles from the former place is a narraw salt lake in a small valley, falling east-south-easterly with spinifex and sand ridges on either side of it and four miles farther on is another narrow lake, or series of lakes, draining south-easterly.

On the north side of this lake is a small outcrop of weathered gneissic granite which is the only rock outcrop noted until the gneiss country near Buninginia was reached. There is a small soak at the foot of these rocks, near the edge of the lake, but it does not look as if it would be in any way permanent.

A mile or so northerly from Buninginia are several low ridges of gneissic granite which trend about north-east and south-west and are for the most part covered with loose sandy soil and densely clothed with spinifex.

At Buninginia there is a large open salt bush and grass flat running south-westerly which is about a mile in width. There is a small flat outcrop of gneissic granite on this flat about half an acre in extent, and on this there is a natural rock-hole holding after rains about a thousand gallons of water. South-westerly from here the salt bush and grass flats with oaks and patches of myoporum are said to extend, with only slight breaks, to Simon's Hill; there is, however, only a narrow strip of this class of country and it is shut in on both sides with mallee and spinifex.

Travelling north-easterly from Buninginia to Goddard's Creek the country for the first six miles consists of loamy flats with oaks, gums, blue bush, and patches of salt bush and grass; at this point (six miles from Buninginia) half a mile or so of lake country is met with, the main lake being a long narrow one only a few chains in width draining south-easterly; over this lake country are salt bush and grass flats. A short distace on the north-east side of the lake a number of pegmatite dykes outcrop which have a roughly parallel trend and vary from a couple of feet up to half a chain in width; they are found over a stretch of nearly a mile and occur in an area of gneissic granite, mostly covered with sand, and are very persistent and regular in their strike. They are coarse-grained and carry a considerable amount of tourmaline, as also does the enclosing gneiss. This locality struck me as one likely to prove tin-bearing, though a brief trial of several of the dykes failed to prove its existence, for the geological conditions are identical with those prevailing on most of the known tinfields.

Outside the main auriferous belt and the smaller one near Cardinia, this, with its southerly continuation, was the only piece of country passed over with even a possible chance of mineral wealth and although the results of the trials made were negative it does not follow that a more detailed search than was possible* may not reveal the presence of mineral deposits, though the chance of this is, I think, a rather remote one.

The gneiss of Simon's Hill and Fraser's Range seems to be portion of this same belt and in the former locality pegmatite dykes similar to those above mentioned were noted but not in the same numbers. On Goddard's Creek some forty miles slightly east of north from Buninginia a small outcrop of a similar gneiss was noted which was apparently the northern continuation of the same belt.

After leaving the lake country there are, in the direction of Goddard's Creek, some six or seven miles of oak and gum flats with

* As my equipment for the carrying out of the whole of this work consisted only of two camels, and my water-carrying capacity was only twelve gallons I was unable to travel as freely as I could have wished, or to spend as much time as I would have liked in certain localities.—C.G.G.

scattered salt and blue bush, and then mallee and spinifex with patches of stunted gum; this latter class of country being continuous easterly some twenty miles or so beyond Goddard's and southerly as far as the eye could reach.

Goddard's Creek, where first struck, is some twenty-seven miles from Buninginia and is running almost due east and west, its bed being from one to three chains in width and formed of loose drift sand. For the whole of the distance traversed it runs through sand plains with dense mallee and spinifex which, as a rule, comes right down to the banks. Here and there along the banks are small patches of wattle and other stock bushes but these, however, are only of a few acres in extent.

From the point where it was first struck the creek was followed west and north to the point where crossed by the survey line, and subsequently traversed some twenty to thirty miles beyond this point for the purpose of proving its connection with the Ponton River.

Goddard's Creek was formerly similar in appearance to what the Ponton River now is farther to the north-west, viz., a typical narrow salt lake with the usual salt gypseous clay bed which has gradually become covered over with drift sand and can be exposed anywhere by digging a few feet down in this sand. The fresh water soaks which are found at fairly frequent intervals along the creek are merely supplies of rain water held in the sand on this clay bottom and are by no means permanent; in digging them out, if the clay bottom is opened up at all, the water rapidly becomes salt, as it also does if drawn upon too heavily.

After leaving the lake country near Buninginia no rock outcrops of any description were seen on the journey to Goddard's and along it to the survey line, the whole country being covered with considerable deposits of sand.

From Goddard's Creek to Queen Victoria Spring, and thence North-East.

From the point where the survey line crosses Goddard's Creek a journey was made to Queen Victoria Spring and thence north-easterly for some distance, for the purpose of examining the auriferous country which had been reported to exist in the locality. My investigations, however, failed to reveal the slightest trace of mineral country in the vicinity of the route traversed, and though such *may* exist—I could not examine every inch of the country—its extent must be so small as to render it of no importance; for my own part I am of opinion that there is no mineral country within, at least, thirty miles of Queen Victoria Spring.

Up to a point about fifteen miles from the spring the country was practically all sand flats covered with a dense growth of mallee and spinifex, the only exceptions being a few small isolated patches of salmon gum a few acres in extent, which were chiefly found between fifteen and twenty miles from Goddard's.

Drifting sandhill country commences at a point fifteen miles from, and is then continuous up to, the spring and also extends for many miles both north and east from it. It is covered with spinifex and carries a few desert gums and pines with occasional small patches of wattle.

Between Goddard's and the spring the only rock outcrop seen was a small patch of weathered granite about a quarter of an acre in extent lying some twenty-two miles along the track.

Queen Victoria Spring is not a spring in the correct sense of the term, it being merely a soak situated in the centre of twenty to thirty acres of grass land surrounded by pines, desert gums, mallee, and spinifex. The soak is in sand on a clay bottom and is apparently formed in an old claypan which has been filled in by drift sand. There was a good supply of water in it when I was there, but it is said to give out after a bad season; it is situated just on the west side of the sand hills and about nine miles west-north-west from Streich Mound. To the south and round through east to north and north-west the country is all sandhills, but to the west and south-west it consists of mallee and spinifex plains which extend across to within a comparatively few miles of Mt. Quinn and Mt. Charles.

Streich Mound is a large round-topped sandhill and is easily the highest point in the district, forming a good guide to the soak, as it can be seen from any high point up to twenty miles distant.

As a general rule the sandhills form long irregular ridges trending roughly east and west and having an average height of fifty to seventy feet, occasionally much more, and the distances between the ridges vary from a few chains up to half a mile or more. Between Streich Mound and the spring, however, the hills have no particular trend but are dotted about all over the place and travelling across them is very heavy on that account.

From Queen Victoria Spring a traverse was made north-easterly, as shown on the map herewith, as it was in this direction and distant about twenty miles that the auriferous country was supposed to exist. My investigations showed all this country—and a good deal beyond it—to be practically all sand hills and certainly not auriferous.

On the outward journey, *i.e.,* going north-east, the country passed over was all sand hills covered with spinifex, desert gums, and pines, with occasional patches of dense mallee. For the first eight or ten miles the sand hills were large and numerous, generally having an east and west trend, but beyond this they got smaller and fewer though they could be seen thick enough a few miles to the north. The flats between them are usually covered with dense mallee and spinifex, the growth over the hills themselves being much more scattered.

From the top of a high sandhill (a) eighteen to twenty miles from the spring, sandhill country could, with the aid of powerful field glasses, be seen extending away indefinitely to the west and

round through north to east; in the latter direction there were twelve to fourteen miles of mallee flats before the sandhills commence.

From this sandhill (a) I went to a second one (b) lying about twelve miles east-south-east, the intervening country being all flat and covered with a dense growth of mallee and spinifex, while at one spot about two miles on the way there was a small outcrop of weathered gneissic granite which was the only rock outcrop seen on this journey. From the top of the second hill (b) sandhill country could be seen extending away indefinitely to the north and east.

Returning from (b) to the spring about ten miles of mallee and spinifex flats, broken in one or two places by small patches of salmon gum with salt and blue bush, were crossed, after which the sand hill country started again and continued to the spring.

On the return journey to the survey line we travelled due south from the spring for a distance of thirty miles, at which point Goddard's Creek (Ponton River) was struck and this was then followed down south-easterly to the point where crossed by the survey line. At a point some six miles from the spring two low sand ridges running east and west were crossed, the balance of the country being practically flat with a general fall to the south and east and covered with dense mallee and spinifex, with the exception of two or three small isolated salmon gum flats each only a few acres in extent. There is generally fair salt bush on these flats and they are the only areas over which any stock feed is procurable.

Goddard's Creek (the Ponton) where first met on this traverse is in a deep well-defined valley which is deeper and better defined to the north-westward where the country is higher; south-easterly the country is falling and the hills and ridges which form the sides of the valley gradually die out in this direction so that a few miles above the point where crossed by the line, and south-easterly beyond it, the creek is merely running through a sandy plain. Its bed varies from two to four chains in width and where first struck the salt-lakelike appearance which it has farther north-west is just disappearing beneath drift sand. A few small patches of gypseous clay and salt still are visible along the bed, but a few miles farther south-east these disappear and the bed is entirely covered with loose drift sand overgrown in places with mallee and ti-tree. The first fresh water soak is found in the sand some ten miles north-west of the line but is not good, the quality of the water and also the supply improving farther to the south-east.

The general trend of the creek from where first met with to the point where crossed by the survey line is roughly south-east and the country through which it runs is of the poorest description, consisting almost entirely of sandplains covered with dense mallee and spinifex. However, there are occasional small areas immediately along the banks of the creek where a little stock feed is procurable, this being mostly wattle and salt bush with here and there small

patches of grass; where these occur the "narrow-leaf" poison plant is also very plentiful.

Some fourteen miles north-west from the line and along the south-west bank of the creek is a low ridge of weathered granite (gneiss) and along the banks of the creek itself is a small outcrop of garnetiferous gneiss which is practically identical in appearance with that noted at Buninginia, Simon's Hill, and Newman's Rocks, and is evidently the continuation of that belt. Owing to the recent deposits (sands, etc.) which cover most of the interior country the extent of this gneissic belt and its relationship to the massive granites farther west could not be determined; it may only be a part of this massive granite which has been rendered gneissic by local pressure, etc., or it may represent an older and entirely different series, and personally I am inclined to the latter belief.

From Goddard's Creek East to the 280-Mile, thence South to the Coast at Eyre, and thence via Balladonia to Simon's Hill.

Going easterly from Goddard's Creek along the proposed line of railway, the sandplain country with mallee and spinifex continues for some twenty-three miles, *i.e.*, to about the 167-mile peg. At one or two places small patches of gimlet wood with salt and blue bush occur within this mallee and spinifex belt, notably near the 157 and the 163-mile pegs. East of the 167-mile peg the mallee and spinifex give place to oaks and blue bush with scattered salt bush, whilst the sand plains are replaced by light-coloured loam flats. This change marks the approximate junction between the granitic country and the tertiary limestone which from this point is continuous easterly across the South Australian border and southerly to the coast. No rock outcrops are visible for a number of miles both east and west of this point (the 167-mile) and as the change in the surface deposits and in the vegetation is a very gradual one and no natural sections could be observed, it is difficult to define exactly the junction between the two formations but it probably runs approximately as shown on the map herewith.

The whole of this limestone area is practically dead level, or at the most slightly undulating, and is covered with a varying depth of light-coloured loam from beneath which flaggy limestone can be seen outcropping every here and there. Along the proposed line of railway there are on this area vast treeless grass and salt bush plains, but nearer the coast there is a fair extent of timbered country.

Over the limestone country the only surface water procurable is obtained from small "rock-holes" which are few and far between, and at best are of very limited capacity. The positions of the principal ones are shown on the map herewith and a fuller description of them will be given later. In addition to the " rock-holes" there are found numbers of what are known as "blow-holes," which are more or less circular openings in the limestone crust from two to six feet

in diameter, through which the air often rushes with considerable force; sometimes the draught is inward and at others outward, consequent on the difference of temperature outside and in. The occurrence of this "blowing" indicates the existence of a system of underground air passages.

Over certain areas in the limestone country there occur also shallow circular depressions in the surface which have been locally termed "dongas"; these vary from five to twenty chains in diameter and are undoubtedly formed by the caving in of subterranean chambers in the limestone.

The southern edge of the limestone tableland is marked by a fairly regular line of cliffs which, westerly from Twilight Cove almost to Israelite Bay, form the coast line and rise vertically out of the sea to a height of 250 to 300 feet. Easterly from Twilight Cove they run back inland from the sea for some miles and then trend roughly parallel to it as far as a point some few miles east of Eucla where they again form the shore line, their greatest distance from it being at a point about half way between Eyre and Eucla where they are some thirty miles inland. They form a more or less vertical escarpment some 200 to 250 feet in height, the country between them and the sea being low-lying loam flats with white drifting sandhills along the immediate sea front. At Eyre these sand hills extend inland for some miles and are formed of very fine white sand; they move comparatively fast and are continually encroaching on the telegraph line, having completely buried the original posts in one or two places.

The cliffs where examined at Twilight Cove are seen to consist of soft shell limestone, apparently horizontally bedded, the upper few feet being very hard and compact, this evidently being due to atmospheric influences. In the faces of the cliffs some distance back from the sea and considerably above its present level, waterworn caverns and wave markings show that at one time the coast here was at a considerably lower level than it is at present and that it has risen at a comparatively recent date.

At the foot of the cliffs at Twilight Cove and in the hollows in the sandhills both here and at Eyre good fresh water is obtainable a foot or two below the surface. The occurrence of this water is referred to later on in Part III. of this report.

On the return journey from Eyre the first change in the formation of the country is noted at Balladonia where the granite rocks again make their appearance, outcropping from beneath the limestone. Their occurrence is in the form of a bold bare outcrop rising to a height of fifty or sixty feet above the surrounding plains and covering an extent of, perhaps, a couple of hundred acres. This granite is a coarse-grained massive variety, its essential constituents being quartz, microline, and biotite with a little magnetite; it contains no garnets. Small veins of pegmatite can be seen traversing the

main mass in all directions, varying in thickness from a fraction of an inch up to nearly a foot.

No actual junction between the granitic rocks, and the limestone, beneath which they dip on all sides at a flat angle, is visible owing to the recent deposits which cover the surface of the country, but there is no doubt as to the granite being the older rock. Several other similar isolated patches of granite occur before the main body is reached, notably at Womberna, twelve miles south of Balladonia, Gerandilla nine miles west, Booma Rocks, Wahgoninya Rocks, etc.

An interesting fact in connection with these granite rocks has been the discovery of diprotodon bones (*Diprotodon Australis*) buried in the sand and silt beside them. Discoveries of these bones have been made at Balladonia, at Cook's Rocks, twenty miles north and at Womberna Rocks, twelve miles south. At Balladonia, bones in a good state of preservation were discovered at depths of from four to twelve feet whilst excavating a dam beside the rocks, while at Cook's and at Womberna fragments of bones were found at from four to eight feet from the surface also whilst excavating dam sites close to the rocks. It is evident that the rocks formerly formed watering places for these animals, as they still do for the present-day fauna, and that the bones are the remains of animals that have either been bogged while at the waters or that have perished as the result of the supply giving out after a bad season, as it still does. It is quite likely therefore that search round any or all of these rocks would result in the further discovery of many of these remains.

Travelling from Balladonia towards Simon's Hill the limestone (plain) country extends for about twenty-four miles, being broken by two small outcrops of bare massive granite eight miles and fifteen miles respectively from Balladonia. The former of these (Booma Rocks) occupies an area of about thirty acres and the latter (Wahgoninya, or "15-Mile" Rocks) slightly more, the granite in both cases being similar to that at Balladonia. Over the limestone area the only rock outcrops are in the form of small isolated patches of flaggy limestone, the bulk of the country being covered with a fair thickness of loose light-coloured loam. Owing to this covering of surface soil no actual junction between the limestone and the main granite belt can be seen and as the change from the light loam of the limestone plains to the sand of the granite country is a very gradual one, this junction can only be fixed approximately; probably however it lies some nine miles west of Wahgoninya Rocks as at this point the gum and salt bush country—here characteristic of the limestone—dies out and gives place to mallee, stunted gums, and patches of spinifex which are characteristic of the granite country. Some four miles beyond this point westerly are several small outcrops of gneissic granite, which were the first outcrops noted after leaving Wahgoninya.

About a mile east of these outcrops is a small narrow salt lake draining to the south, the country on each side consisting of low sand ridges with mallee and spinifex; this class of country is then continuous until Newman's Rocks are met with; here there is a considerable outcrop of granitic rocks which occupy an area of sixty or seventy acres and rise in places up to fifty or sixty feet. The rock is a garnetiferous biotite gneiss and is similar to that noted on Goddard's Creek.

On the east side of these rocks is a series of narrow salt lakes which have a total width of about half a mile and drain towards the south, evidently extending for a considerable distance as they can be seen some miles to the north-east and are here in a well-defined, though not deep, valley.

There are several shallow soak wells at the foot of the rocks and a small patch of good country round them, but at a very little distance the sand plains with mallee and spinifex start again and are then continuous almost to Simon's Hill.

Around Simon's Hill there are a number of low-rounded hills and ridges which are the north-east end of Fraser's Range and rise at their highest point a hundred and fifty to two hundred feet above the plain. The rock of which these hills are formed varies from a garnetiferous quartz schist to a garnetiferous biotite gneiss and is evidently a continuation of the Buninginia-Goddard's Creek gneiss belt. Several coarse-grained pegmatite dykes were noted running through the gneiss and one of these some six miles south-east of Simon's Hill has been opened up to a depth of six or eight feet in a couple of places, evidently in a search for mica, masses of which, up to two or three inches square, are common enough in the dyke, which is from six to ten feet in width; fair-sized crystals of tourmaline are also common in it, and one small pink one of poor quality was also noted.

From Simon's Hill to Lake Cowan, Binyerinyina and Kanowna.

After leaving Simon's Hill the country is—with the exception of one small patch of granite rocks—all undulating sand plains, mostly covered with mallee and scattered spinifex, until Lake Cowan is reached. The granite of which the above patch of rocks is formed is of the massive variety as are all the outcrops noted to the west of this point. Some nine to ten miles from these rocks, towards Lake Cowan, a small salt lake was crossed and a second larger one some nine miles farther on; the latter being apparently an offshoot off the northern portion of Lake Cowan; both these lakes are draining to the south and south-west.

Round the north-east end of the main body of Lake Cowan are low ridges of drift sand covered with stunted pine trees running back a quarter to half a mile, and behind them, extending back a couple of miles from the lake, are sand and loam flats. A narrow

arm of salt lake, often less than a chain wide, winds through these flats at the north-east end of the main body of Lake Cowan and unites it with another good sized series of salt lakes lying a few miles to the north-east.

On the north side of this arm the greenstones were again met with for the first time after leaving Cardinia; here they outcrop over a small area and are highly foliated and much weathered, and numerous granitic dykes can be seen running through them, these having a general north-west and south-east trend. Only a narrow strip—about a mile or so—of these greenstones was passed over, the track soon coming on to the granitic area again; they mark the south-western extremity of the main Randells-Bulong-Kurnalpi belt, the boundary between them and the granitic rocks being approximately as shown on the map herewith.

At Binyerinyina is a large outcrop of bare granite rocks which are of the usual massive variety; they lie a couple of miles from the west shore of Lake Cowan and rise from an extensive open sandy flat to a height of fifty or sixty feet. There is a good supply of water in shallow soak wells at the foot of these rocks.

After leaving Binyerinyina no rock outcrops were seen until a point some six miles to the north was reached; here there are a few low broken ridges of granite trending east and west and extending north for about four miles, where they reach their highest point; up to here the drainage of the country is all southerly into Lake Cowan, but beyond this it is northerly to Lake Lefroy. After crossing these ridges no further rock outcrops were seen until the north side of the lake country was reached, when the greenstone of the main belt were met again, outcropping along the shores of the lake, and then at frequent intervals right across to the survey line.

Twenty-five miles north from Binyerinyina a series of salt lakes was met with which extend over a width of about six miles and trend east and west, being evidently a continuation of Lake Lefroy; the widest extent of actual lake bed is about two miles—this being the northerly arm—while there are several other arms over half a mile across.

After crossing the lake country the route followed lay entirely over greenstone country, this being the main Mt. Monger-Randells, etc., belt. The greater portion of the belt where crossed is covered with extensive recent reposits (loam, etc.), but a few miles both east and west of the track are low broken ranges over which the rocks outcrop and in which the mining centre of Randells and Mt. Monger are situated.

Some three or four miles before the survey line was reached a small belt of granite country was passed over, but owing to the recent deposits the boundaries of this belt were not exactly definable, though it appeared to be about a mile across and is evidently only a small offshoot from the main body farther east. One or two somewhat similar but smaller bodies of granitic rocks were

also noted between the end of the wood line (32-mile) and Kanowna, but these, however, are of no great extent or importance.

Part II.—Mineral Possibilities.

As regards the mineral possibilities of the country lying within, say, a 70 to 80 mile radius of the proposed line of railway, it can be stated at once that both the granitic and the limestone formations which, as can be seen by reference to the map, occupy the whole of the country passed over after the first seventy miles, are non-auriferous and, with the exception of the one district mentioned below, hold out no possibility of the discovery of mineral wealth of any description.

This one excepted district is that occupied by the belt of garnetiferous gneissic granite which outcrops at Simon's Hill, Buninginia, Newman's Rocks, and Goddard's Creek. The whole of this belt, however, with the exception of comparatively small areas at the localities mentioned, is covered with extensive sand plains which render it valueless for prospecting purposes. At Simon's Hill and in the vicinity of Buninginia numbers of coarse-grained pegmatite dykes can be see cutting through the gneiss, being especially numerous at a point some half dozen miles north-east from Buninginia. These dykes carry a considerable percentage of tourmaline, as also does the enclosing gneiss, and from their appearance, etc., struck me as being possibly tin-bearing, though a somewhat short examination of them failed to show any.

When passing through Balladonia a specimen of allanite (silicate of lime, iron, aluminium, and cerium) was handed to me which was reported to have been found in one of these pegmatite dykes near Simon's Hill; this mineral, though of itself of no great commercial value, is of considerable scientific interest, but I was unable to ascertain if it were present in the dyke in any quantity, but the probability is that it was not. It is quite probable that where it was found the closely related mineral gadolinite will also be obtained, but this, although it has at the present time a considerable market value on account of its yttrium contents, can hardly be looked upon as a commercial mineral in the general sense of the term.

Near Simon's Hill also, as mentioned in the first part of this report, one of these dykes has been opened up to a depth of six or eight feet in two or three places apparently in search for mica; irregular masses of this up to a couple of inches square are common in the dyke, but as far as opened up it is of poor quality and of little or no value. In this dyke also a small pink tourmaline was noted; these when of good quality are of considerable value as gems, but the likelihood of their being found here in payable quantities is not great.

As, however, neither tin nor any other commercial metal or mineral has been found in it in payable quantities and the possibility of their existence is after all only a faint one, I am not inclined to consider this belt of country as a mineral one, and will say that, in my opinion, the only country of any mineral value lying within at least a seventy-mile radius of the proposed line of railway is that found within the first sixty-nine miles of the surveyed line. This embraces the two greenstone (auriferous) belts mentioned in the first part of this report and shown on the map herewith, viz., the main Kurnalpi-Bulong, etc., belt and the small belt lying west and north of Cardinia.

This second belt has a probable length of some fifteen miles and an average width of about three miles. The rocks are greenstones of the usual type and are somewhat foliated and schistose; quartz reefs are fairly plentiful and are sometimes of considerable size. The belt has been run over by prospectors, but no systematic prospecting has been done, and the general appearance of the locality certainly warrants more attention than it appears to have received.

The extent of the first, or main, belt is shown on the map accompanying this report, and, as can be seen, the whole of this district is within fairly easy access of the various outlying settled centres —Kurnalpi, Bulong, Kurramia (Wood line), Randells, and Mt. Monger—and has received considerable attention from the prospector. There is, however, within it a considerable extent of country which is well worthy of further attention, this being particularly the case with that portion lying to the east and north-east of Kurnalpi; here some very nice looking country was passed over which, judging by appearances, has not received much prospecting.

It can, however, hardly be said that either of these belts are "new" country for they have both been known to, and have received attention from, prospectors for a good number of years back. Neither can it be said that the construction of the proposed railway will to any great extent tend to open them up for the most outback portion of them is, as before stated, within fairly easy access of already settled centres, and in view of this fact it can be said that, broadly speaking, the construction of the proposed line will open up no mineral country.

Part III.—Water Supply.

Relative to the water supply along the proposed railway, it can be briefly stated that the whole of the first hundred and eighty miles is practically a waterless stretch; there are certainly a few rock holes and soaks along it, but these are not permanent, and the supply is very limited. Moreover, boring operations have so far failed to prove the existence of an underground supply of fresh water and, as far as the country travelled over by myself goes,

I hardly think a supply is likely to be found, *i.e.*, before the limestone country is entered upon, unless it be at a spot about eight miles south of the 115-mile peg on a large salt bush and grass flat at the south-east end of a well defined watercourse falling in this direction. There appears to be a good drainage from at least three sides into this flat, and it was the only place seen by me which gave even a faint hope of the possibility of obtaining fresh water at a fairly shallow depth.

Salt water will, of course, be procurable at a shallow depth along any of the systems of salt lakes.

As regards a supply for the railway over this first stage, the only way of procuring it will be by the construction of tanks and the conservation of the surface supply (rain water) and practically the only place along the line where a decent tank site and catchment is available is at Cardinia Rocks (69-mile).

Along the section of the line lying over the limestone tableland, water will always be procurable by deep boring, but the quality will, judging by previous results, possibly not be too good, and, in addition, it will in all probablity have to be pumped from a depth of several hundred feet, owing to the flow not reaching to the surface for reasons given below.

The strata of which this tableland is formed consists of porous tertiary limestones, with underlying soft sandstones and clay shales; these beds appear to me to be laid down practically horizontally, though a slight prevailing dip to the south, *i.e.*, towards the coast, has also been ascribed to them. On the north the water-bearing beds do not outcrop, but presumably impinge directly on the granitic rocks, and receive a large portion of their water along this junction.

On the South Australian side of the border, bores show that the upper sandy water-bearing beds are overlain by three hundred to five hundred feet of porous limestone; these water-bearing beds outcrop at sea level, and being practically horizontal, are also overlain on the Western Australian side by two hundred and fifty to three hundred feet of limestone (the height of the cliffs) near the coast, which increases to five to six hundred feet farther inland owing to the gradual rise of the surface of the country. A second main water-bearing series appears to exist at a depth of 1,000 to 2,000 feet below the upper one, the intervening porous rocks also being more or less saturated with water. The occurrence of this lower water-bearing series is proved by the bore at Madura (W.A.), in which a flow of water was struck at a depth of a little over 2,000 feet and rose to the surface.

This lower series could be tapped by bores anywhere inland within the limestone area, but, owing to the fact that the surface of the country varies from 250 feet, at the cliffs on the coast, to 550 feet, along the railway line, above sea level, and also that there is a known outlet for the water along sea level—proved by the presence of surface springs at the foot of the cliffs at Twilight Cove

and on the shore at Eyre—the probability is that the water will not rise to the surface, though there will probably be sufficient pressure, due to the natural resistance to horizontal flow, to make it rise considerably above sea level. The bore at Madura is stated to be put down at the foot of the cliffs, a very few feet above sea level, and the flow, even here, is only a foot or so above the surface ; the supply is put down at 5,700 gallons per day (from 2,040 feet) and is said to be good stock water.

In five bores put down on the South-Australian side of the border, water was met with at depths of from 700 to 1,200 feet, but in no case did it rise to the surface ; the supply varied from strongly brackish to good stock water.*

A bore put down at a point twenty-five miles north of Madura struck the upper water-bearing series at about 430 feet (about sea level), and the supply is said to be good stock water, but it has to be pumped from the bottom of the bore. This upper series will be met with over the whole basin at about sea level, the supply will be plentiful and probably of better quality than that met with at the greater depth ; it will however not rise to the surface and will always have to be pumped.

In connection with the question of artesian or sub-artesian water in this district, the following extracts are taken from a report† by the Government Geologist of this State written in 1900 and from a report‡ by the Government Geologist of South Australia written in 1885. The first of these reports reads as follows:—

". . . . . The strata consist of porous limestone associated with beds into which the rainfall is rapidly absorbed and discharges seawards in the form of fresh water springs, rendering the occurrence of underground water more than probable. These beds have been pierced by means of five bores on the South Australian side of the border. The section in these bores invariably shows a thickness of sandy water-bearing beds covered by limestone from 300 to 500 feet thick. The beds have a slight prevailing dip towards the Great Australian Bight, and the water (sub-artesian) rises in the bore holes to a height equal to that of the sea level. So far, however, the water obtained has proved to be either salt or brackish, but still suitable for stock purposes . . . . I am, however, not very sanguine of success in obtaining anything but a sub-artesian supply of water anywhere towards the northern edge of the Tertiary basin. Any such supply would be expected to be at least brackish though no doubt suitable for stock . . . "

In the second report Mr. Brown says:—

" . . . There is every probability of good water being obtained by boring through the limestone of the Nullabar Plains into

* See Annual Report of the Geological Survey, 1900, pp. 29 and 30.

† Extension of Artesian Water-carrying Strata from South Australia : by A. Gibb Maitland, Government Geologist. Annual Report Geological Survey, W.A., 1900, p. 28.

‡ A Report on the Geological character of the country passed over from Port Augusta to Eucla : by H. Y. L. Brown, Government Geologist, Adelaide. By authority, 1885.

the sandstone, clay, and sand beds which will be found beneath it. It is not probable that water met with in boring here will rise to the surface, taking the high elevation of the plain into consideration and the certainty that outlets exist to the southwards where the sea level is from 250 to 300 feet lower than the surface of the plain. Sufficient pressure might, however, remain to force the water to a considerable height in the bore . . . . ."

Over this limestone tableland the only surface water procurable is found in small rock holes which are more or less circular holes worn in the upper crust of the limestone and holding up to, in one case, 20,000 gallons of water; their more usual capacity is, however, from 500 to 1,000 gallons. They hold water only for a comparatively short time after rain and are not to be relied upon for a supply during the summer months; and at best they are but few and far between.

The positions and holding capacity of the most important of these rock holes are shown on the map accompanying this report.

With regard to the supply of surface water over the route followed by myself along and away from the survey line, the following are descriptions of the principal rock holes and soaks, exclusive of those in the limestone and along the stock route which are shown on the map:—

Cardinia.—Several small rock holes and soaks at foot of large granite rock. Good supply of fresh water during the greater part of year, but it is said not to be permanent.

Jumannia.—Rock holes. 2,000 gallons.

Erayinia.—Small rock holes; supply poor. Small rock hole (100 gallons) 7 miles south-south-east.

Beerie.—Small rock hole; 200 (?) gallons.

Yindi.—Good rock holes and shallow soak wells; supply good.

Ponton River (*North side*).—Small rock hole; 100 gallons.

Eudarie.—Rock hole, 200 gallons, and small soak at foot of rock.

Buninginia.—Rock hole, 1,000 gallons. A small soak at edge of lake half-way between Eudarie and Buninginia.

Goddard's Creek.—Numerous soaks along the sandy bed of the creek; supply good, but is said to give out after a bad season.

Queen Victoria Spring.—Soak in sand on clay bottom; good supply in average seasons, but is said to give out after a bad one.

C. G. GIBSON,

Assistant Geologist.

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By Authority: Fred. Wm. Simpson, Government Printer, Perth.

Photo. C. G. Gibson.

Granite Rocks, Cardinia.

Photo. C. G. Gibson.

Rock Hole in Granite, Jumannia.

Photo. C. G. Gibson.

View on Ponton River. N. from 102 M.P.

Photo. C. G. Gibson.

Granite Rocks, 5m. N. of Ponton River.

Photo. C. G. Gibson.

Quartzite-capped Hill near Eudarie.

Photo. C. G. Gibson.

Eudarie Rock (Granite).

Photo. C. G. Gibson.

Gnamma Hole, Eudarie Rock.

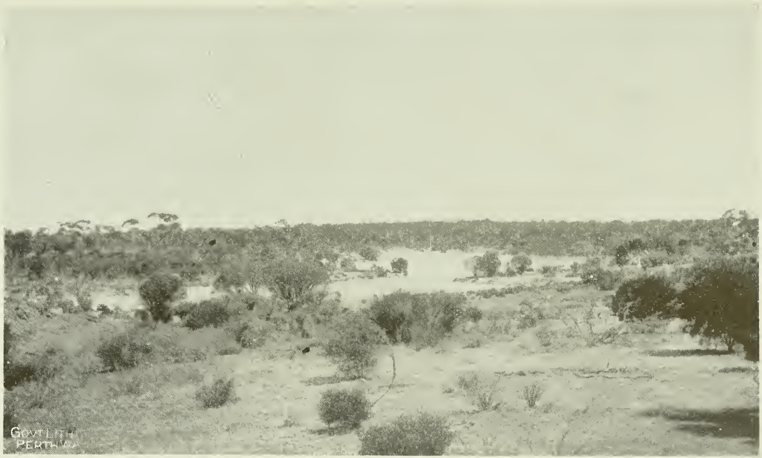


Photo. C. G. Gibson.

Small Salt Lake 9m. N.N.W. from Buninginia Rock.

Photo. C. G. Gibson.

Sand Soak, Goddard's Creek.

Photo. C. G. Gibson.

Camels at small Rock Hole in Limestone.

Photo. C. G. Gibson.

Main Survey Party getting water at Rock Hole in Limestone near 243 M.P.

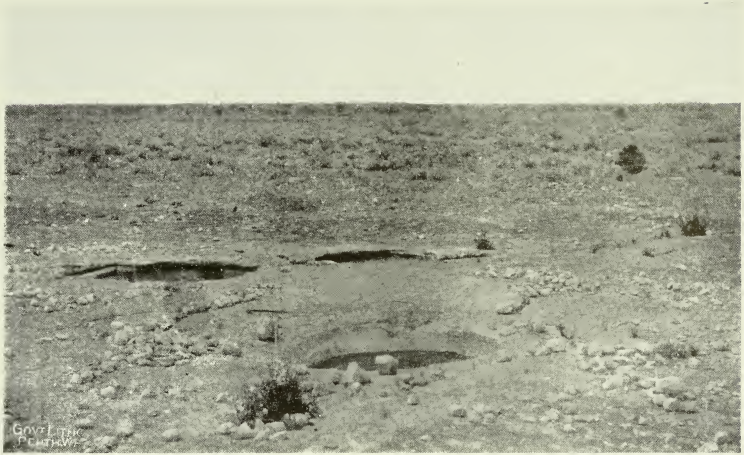


Photo. C. G. Gibson.

Rock Holes in Limestone near 220 M.P.

Photo. C. G. Gibson.

Limestone Cliffs near Twilight Cove.

Limestone Cliffs near Twilight Cove.

Photo. C. G. Gibson.

Photo. C. G. Gibson.

Limestone Cliffs near Twilight Cove.

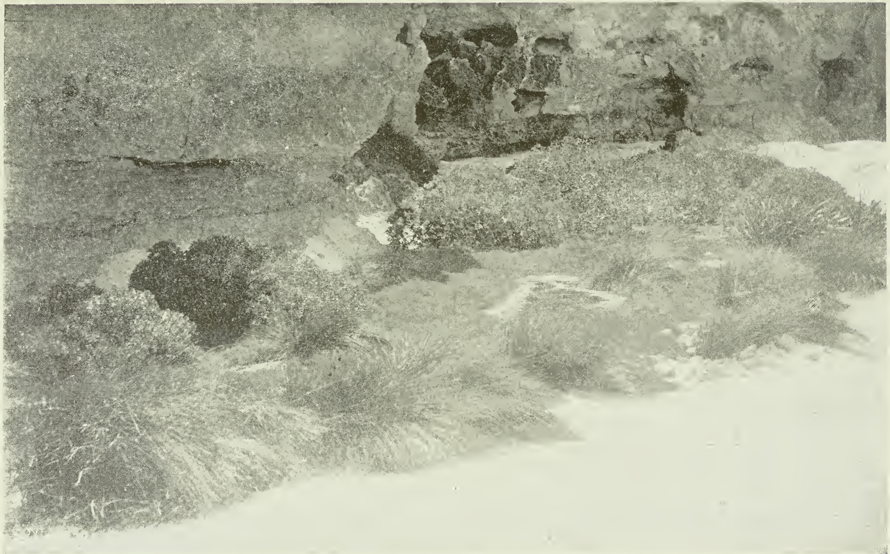


Photo. C. G. Gibson.

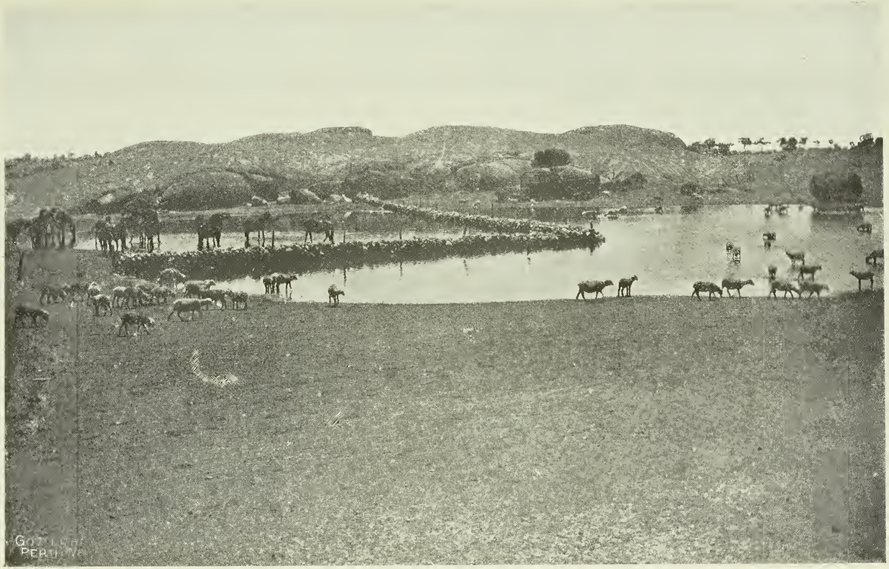
Fresh water Spring at foot of Cliffs, Twilight Cove.

Photo. C. G. Gibson.

Water-worn Cave in Limestone Cliff, Twilight Cove.

Photo. C. G. Gibson.

Drifting Sand-hills, Eyre.



Granite Rocks, Balladonia.

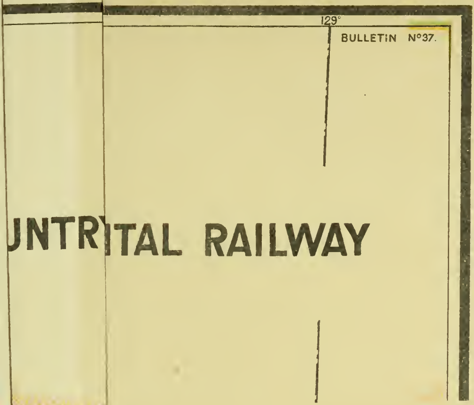
Photo. C. G. Gibson.

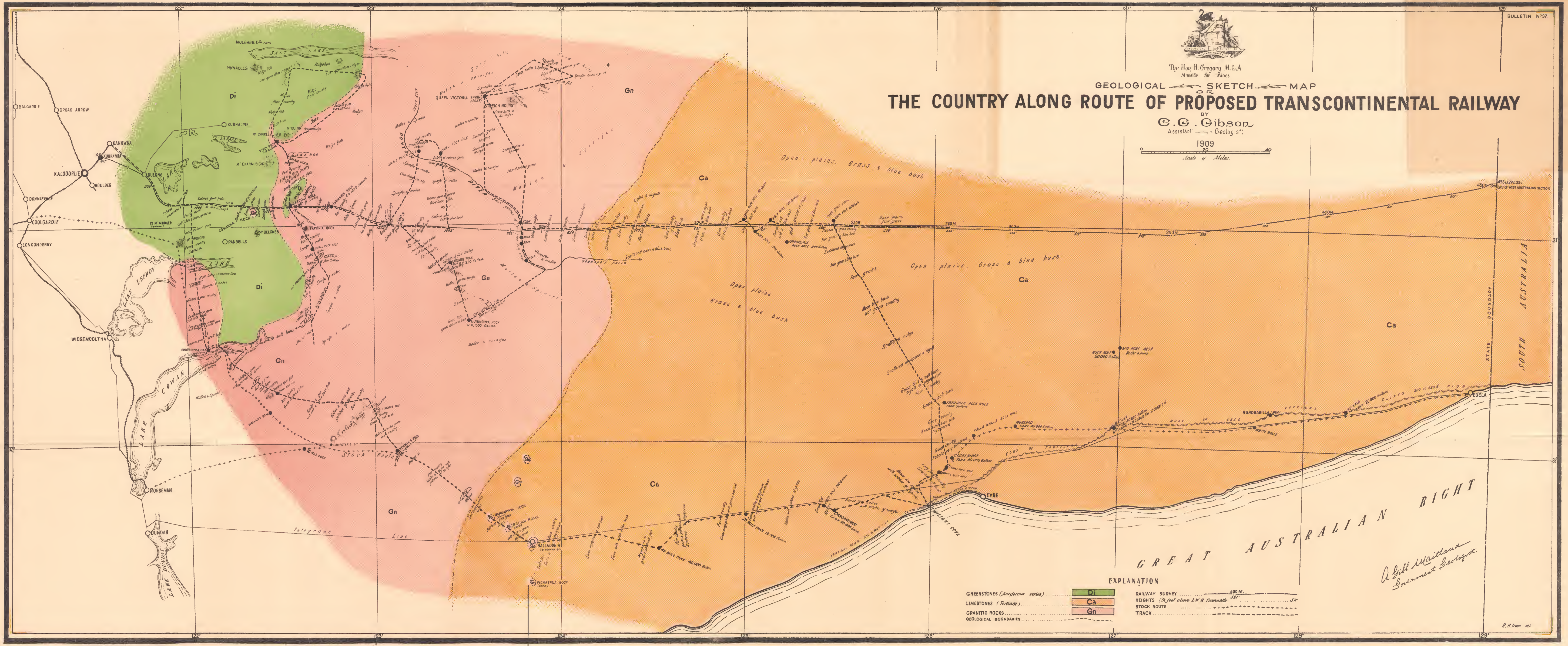
Photo. C. G. Gibson.

North end of Lake Cowan.

Photo. C. G. Gibson.

Camels crossing the North portion of Lake Lefroy.


129°
BULLETIN N°37.
UNTR ITAL RAILWAY



H.J. Pether, Government Lithographer, Perth. W.A.